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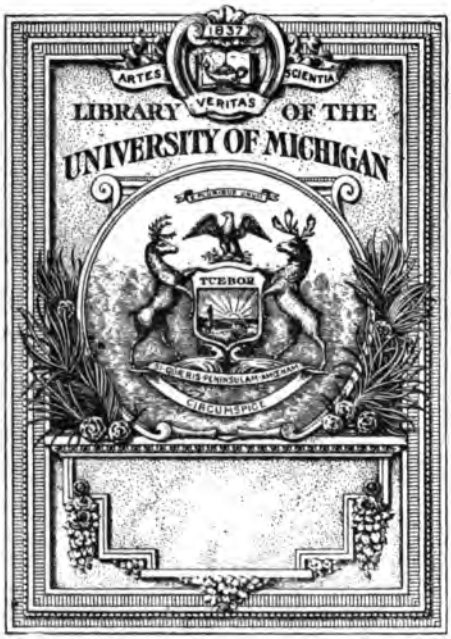
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QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

EDITED BY

A COMMITTEE OF THE COUNCIL.

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Royal Meteorological Society.

Established 1850. Incorporated by Royal Charter, 1866.

Office:—30 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1889.

ORDINARY MEETINGS at 7 p.m.

Wednesday, January*	16,	1889.
,, February	20,	,,
,, March	20,	,,
,, April	17,	,,
,, May	15,	,,
,, June	19,	,,
,, November	20,	,,
,, December	18,	,,

* Annual General Meeting.

EXHIBITION OF INSTRUMENTS,

March 19th to 22nd, 1889.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

NOTICE.

The Library and Offices of the Society are open daily from 10 a.m. to 5 p.m.; Saturdays, 10 a.m. to 2 p.m.

The Society is not responsible for the views and opinions advanced in the *Quarterly Journal*.

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VOL. XV. JANUARY 1889. No. 69.

RESULTS OF AN INVESTIGATION OF THE PHENOMENA OF ENGLISH THUNDERSTORMS during the Years 1857-59.

BY G. J. SYMONS, F.R.S., SECRETARY.

[Received October 17th.—Read November 21st, 1888.]

[The following paper was written nearly thirty years ago, and was read by me at the Oxford Meeting of the British Association in 1860. As, however, only a very brief abstract of it was published, and the Members of the Thunderstorm Committee of the Royal Meteorological Society are of opinion that it contains facts worthy of attention, I have, at their suggestion, submitted it for the acceptance of the Society. I offer no apology for its style or arrangement, but leave it as it was. It will, however, probably be well to explain that it was the fourth report, and the summary of work, upon thunderstorms to which I had devoted much time in the years 1857, 1858 and 1859, having established a small organisation analogous, but naturally inferior, to the one recently started by the Royal Meteorological Society.]

RESULTS OF AN INVESTIGATION OF THE PHENOMENA OF ENGLISH THUNDERSTORMS DURING THE YEARS 1857-8-9. By G. J. SYMONS, M.B.M.S., &c.

THE following pages contain a summary, chiefly in statistical form, of some of the results of an investigation which I have been carrying on during the

last three years into English thunderstorms, and the accidents produced by lightning. In this inquiry it is obvious that I must have received assistance from a large number of persons, so large, indeed, that it is impossible to make more than this general acknowledgment of my indebtedness to some hundreds of correspondents.

DAYS OF THUNDERSTORM—*i.e.* DAYS IN EACH MONTH ON WHICH A THUNDERSTORM WAS REPORTED FROM SOME ONE STATION.

Months.	1857.	1858.	1859.	Mean.
	Days.	Days.	Days.	Days.
January	3	1	6	3·3
February	1	0	4	1·7
March	10	1	7	6·0
April	17	11	9	12·3
May	18	24	11	17·7
June	19	21	20	20·0
July	12	16	11	13·0
August	16	15	11	14·0
September	14	13	10	12·3
October	9	5	15	9·7
November	6	4	7	5·7
December	1	7	9	5·6
Totals	126	118	120	121·3

NUMBER OF OBSERVATIONS.

Months.	1857.	1858.	1859.	Mean.
	No.	No.	No.	No.
January	5	1	6	4·0
February	1	0	4	1·7
March	33	1	23	19·0
April	61	54	30	48·3
May	74	83	85	80·7
June	116	194	138	149·3
July	58	119	90	89·0
August	164	118	33	105·0
September	62	95	28	61·7
October	24	16	63	34·3
November	6	10	22	12·7
December	1	36	35	24·0
Totals	605	727	557	629·7

COLOUR OF LIGHTNING.

Colours reported in 1857.

March 15. CHEPSTOW, red.
,, 31. BELVOIR, blue. Violent thunderstorm in afternoon.
,, ,, MANCHESTER, reddish. Slight storm 1 p.m.
,, ,, THWAITE, yellow. Sharp storm at 3 p.m.
May 28. CLIFTON, yellowish. Violent storm at some little distance.

NUMBER OF ACCIDENTS IN 1857–59.

	1857.	1858.	1859.	Total.
Men killed	4	7	8	19
Woman ,,	1	..	..	1
Men injured	8	18	23	49
Women ,,		7	4	11
Horses killed	2	20	2	24
,, injured	..	2	..	2
Oxen killed	1	2	2	5
,, injured	1	..	..	1
Sheep and Lambs killed	15	43	21	79
,, ,, injured	..	2	..	2
Cat killed	1	..	..	1
Dog ,,	..	1	..	1
Pig ,,	..	1	..	1
Churches injured	2	4	4	10
Houses ,,	11	17	14	42
Chimneys ,,	3	7	2	12
Barns and Stables injured	2	3	..	5
Mills ,,	1	1	..	2
Flag Towers ,,	2	..	..	2
Railway Station ,,	1	..	..	1
Engine House ,,	1	..	..	1
Gasometer ,,	1	..	..	1
Ricks ,,	2	..	1	3
Vessels in Harbour ,,	2	..	..	2
Trees ,,	12	5	11	28
Schools ,,	..	2	..	2
Railway Train ,,	..	1	..	1
Waggon ,,	..	1	..	1
Telegraphic Apparatus injured	..	3	..	3
Totals	73	147	92	312

N.B.—This Table is undoubtedly extremely incomplete, probably not one quarter of the true total,—it merely gives the instances reported to the writer.

June 6. THWAITE, "red sheet, and blue curved." Violent thunderstorm at 8 p.m.

,, 10. THWAITE, vivid yellow, forked. A heavy thunderstorm at 2.15 p.m.

,, ,, UCKFIELD, whitish, not forked, slight storm at 0.45 p.m.

,, ,, ,, blue, not forked. Second thunderstorm at 8.3 p.m. on this day.

,, 19. LONDON, white and yellow when distant, but blue and rose when violent, about 1 p.m.

,, ,, UCKFIELD, intensely blue, very forked about midnight.

,, 29. MANCHESTER, white, tinted with red and orange, forked, about 9 p.m. when storm distant.

,, ,, MANCHESTER, one *vivid* reddish yellow, and one "*vivid* purplish pink" during the height of a storm at 8.30 p.m.

,, ,, WAKEFIELD, rose, zigzag flashes, about 5 p.m.

,, 30. THWAITE, as sulphur flame, curved, about 4.15 p.m.

July 1. LONDON, pale red, sheet, at noon.

,, 9. UCKFIELD, reddish, not forked, at 1.11 p.m.

Aug. 13. LONDON, bluish white, violet, blue, yellow in south, sheet most brilliant 9.35 p.m.

„ 14. LONDON, white was accompanied by artillery-like thunder; blue by dull though loud thunder. The nearest and strongest clap was attendant on a violet flash, and violet often played over rose; this was during a violent storm from midnight of 13th to 2 a.m. 14th.

„ 13. BELVOIR, blue, sheet, but occasionally forked and foliated. Thunderstorm.

„ 14. BELVOIR, blue, sheet (several accidents in the neighbourhood).

„ „ MANCHESTER, blue, forked. Thunderstorm at night with much rain.

Colours reported in 1858.

April 16. LONDON, pale lilac, sheet, slight storm about 9 p.m.

June 8. „ as lightning became more distant it became "slatish white;" this was between 11 p.m. and midnight.

„ „ MANCHESTER, pinky white, sharp thunder about 5 p.m.

„ „ WIBSEY, school struck. Yellowish white with a tinge of blue.

„ 5. THWAITE, red. Thunderstorm and large hail.

„ „ LONDON, red and violet, sheet and forked, with "Pocky Cloud" in early morning.

„ 9. RYTHER, school struck. Bright red.

„ 12. BELVOIR, yellow, sheet. about 2.30 p.m.—not a bad storm.

„ „ WAKEFIELD, blue and pink, sheet, with heavy rain.

„ 15. MANCHESTER, orange, distant, about 5 p.m.

„ 16. „ purplish white and the nearer flashes about midnight, *blue*, forked.

„ 15. LONDON, white and yellowish white, distant; about 11 p.m.

„ 16. „ white, distant, 9 p.m. to midnight.

July 7. „ white, pink and violet. House struck close by. Violent at 3.16 p.m.

„ 18. MANCHESTER, bluish white, forked, 1 p.m.

Aug. 12. LONDON, red and pink, forked but distant, about 6 p.m.

„ „ MANCHESTER, purplish white, sheet or forked below the horizon, at 9 p.m.

„ „ DERBY. Mr. Moore, a gentleman struck by lightning, said:—"We appeared enveloped in a thin bluish flame."

Sept. 17. LONDON, red, pink, some slate, distant, 8 to 11 p.m.

„ 22. THWAITE, blue. Thunderstorm.

„ „ MANCHESTER, purplish white, forked, about 6 p.m.

Colours reported in 1859.

May 29. OUNDLE, pale yellow, sheet, mostly distant.

„ „ MANCHESTER, white, forked but distant, at 7.45 p.m.

„ 31. OUNDLE, white, sheet, mostly distant.

June 26. WAKEFIELD, rose, sheet, about 9 a.m.
July 2. LONDON, violet, forked and very grand, about 10.50 p.m.
,, 18. ,, blue and yellow, various, much sheet, about 11 p.m.
,, ,, OUNDLE, red, pale yellow and blue, sheet, distant storm at 11.30 p.m.
July 18. BELVOIR, pink, sheet, at 6.20 p.m., blue, sheet, at midnight.
,, ,, MANCHESTER, white, forked but distant, about 6 p.m.
,, ,, WAKEFIELD, yellowish, but on nearer approach rose; the most vivid flash at 7.26 p.m. was violet.
Aug. 25. OUNDLE, pale yellow, forked, but not severe.
Dec. 30. LEICESTER, beautiful rose with a tinge of violet. Thunderstorm about 4 p.m.
,, ,, THORNTON, LEICESTERSHIRE,
,, 3.34 p.m., *vivid* bright yellow, TI[1] = 0m.0s.
,, 3.36, yellow.
,, 3.37, *pale* yellow.
,, 3.41, *vivid* pink.
,, 3.51 ,,
,, 3.54 ,,
,, 3.55 ,,
} "A most beautiful pink—so rich a colour I do not think I ever saw before."

REMARKS ON THE RESULTS OF THE PRECEDING TABLES.

In examining the returns with reference to the colour of the lightning, I find that the results afforded by the different years present a close accordance in their indications.

I may perhaps, before stating the results obtained, explain that I have been obliged either to reject or reduce to some of the primary colours the terms employed by some of the observers, such as "like sulphur flame," "like a burning rope," "mauve," &c. On separating the records into the two classes of Sheet and Forked Lightning, I find that in Sheet Lightning the most prevalent colour is white, then yellow, blue, and red; in Forked Lightning, however, the order is nearly reversed, blue being more than twice as frequent as any other colour, then red, white, and most rarely yellow. Blue (or violet) is by far the most frequently recorded colour.

In every case but two where I have received communications from persons who have been themselves, or whose houses have been, struck by Lightning, and the colour has been mentioned, it has been stated to be blue or violet. The exceptions were red at Rythor School, and yellowish-white with a tinge of blue at Wibsey, near Bradford.

Sheet Lightning is seen about twice as often as Forked.

Some of my own observations have led me to infer that the colour ascribed to Lightning varies with the distance of the discharge from the observer, with the density of the air through which it passes, and with the existence or

[1] TI = Time Interval, *i.e.* the interval between the lightning being seen and thunder first heard.

absence of other sources of illumination; but this is at present merely a conjecture and requires confirmation.

Two analyses of these returns have yielded the following results:—

COLOUR OF LIGHTNING INDEPENDENTLY OF ITS CHARACTER.

	Blue.	White.	Yellow.	Red.
1857 ...	12	6	6	8
1858 ...	13	8	4	8
1859 ...	6	4	6	6
Totals ...	31	18	16	22

COLOUR OF FORKED LIGHTNING.

Blue.	White.	Yellow.	Red.
13	6	3	6

COLOUR OF SHEET LIGHTNING.

Blue.	White.	Yellow.	Red.
9	13	10	9

Therefore Forked Lightning is twice as often blue as any other colour, next to which come red and white, and most rarely yellow. But of Sheet Lightning the most frequent colour is white, then yellow, blue, and red. If we neglect the description of Lightning, then the order is blue, red, white and yellow.

BALL LIGHTNING.

1858. June 3rd.—On the farm of Mr. J. Stacy, Shippon, near Abingdon, Berks, a number of sheep, terrified by the violence of a storm, had collected in one corner of their fold; some men who were sheltering at a distance of about 100 yards state that "a ball of fire, apparently no larger than a quart cup, fell among the sheep and killed 25 of them; a considerable cloud of smoke came from that part of the fold where the ball fell, it was carried by the wind above two furlongs, and smelt very strongly of sulphur."

June 3rd.—A man who was looking out of a window at Greenholme Mills, Otley, Yorks, states that he saw a ball of fire drop into the river a few yards from the window at which he was standing. He was knocked down.

June 26th, RUBISLAW BLEACHFIELDS, ABERDEEN. Dr. Cruickshank says:—"The lightning on striking the chimney appeared like a cricket ball of the brightness of iron at a white heat; this instantaneously passed into that of a bluish flame, a little darker than that of common salt when thrown on the fire. A momentary flicker was perceived, and a sharp crack was heard.

1859. July 17th.—A house in Camden Square, London, only about 200 yards from my own residence, was struck by, as a friend describes it, a ball of fire about the size of a man's head, which, on striking the chimney, seemed

to split into two hemispheres. I did not myself see it, as I was looking in another direction; I merely saw an intensely vivid violet coloured flash.

July 21st.—Some men who were at work state that the lightning which injured Mr. Payne's house at Southampton was like a ball of fire falling on the roof.

Disruptive Force.

1857. August 18th.—About four tons of stone parapet was displaced at Windsor Castle.

August 14th.—A pinnacle of St. Michael's Church, Stamford, weighing about one ton, was overturned.

1858. June 3rd.—Shippon, near Abingdon. Mr. Stacy writes: "The sheep seem to have been almost forced into the ground."

June 3rd.—Bradford. Mr. Haining writes:—"The beam in my attic was completely shivered; and in another house in the same town the fire-grate was sent into the middle of the room."

1859. July 18th.—A factory chimney at Wakefield, about 100 feet high and built of brick, was more or less injured throughout the greater part of its length. As nearly 50 square feet of brickwork was thrown down from the upper part, and an irregular fissure extended to the base of the shaft, we shall probably under-estimate the force exerted if we state it to have been 700 tons. No conductor.

July 19th.—Driffield, Yorks. The injury done to a chimney 84 feet high is thus stated:—"One-third of the stone top was thrown down, the rest loosened; the lightning then passed into the brickwork, which on three sides (it was octagonal) it split and shattered in all directions through a space of 25 feet, completely detaching portions of the brickwork several feet in length both inside and out; it then split the remainder of the shaft in a straight line (15 feet long) to the stone base, which it also displaced, then split 7 feet more solid brickwork, and escaping through a ventilator into the roof of an adjoining warehouse it shattered and split the main timbers." This is, I believe, the most violent shock which has occurred during the three years, and I regret that, owing to defective information and to some of the quantities being unknown, I cannot determine the force exerted. No conductor.

1859. July 21st.—A house was struck near Gloucester, and a piece of the skirting-board of the sitting-room was picked up at a distance of about 130 feet; of course the furniture, &c., was all broken.

1859. December 30th.—Nearly 15 feet of the stone work of the steeple of Caythorpe Church, Lincolnshire, was knocked down, and fissures made in other parts.

Effects of Lightning on the Human Body.

Part I.—*In cases of Death.*

1858. June 3rd.—The boy killed at Wibsey had a mark about the size of a sixpence on the sole of one foot. His body seemed as if parboiled, and in two days it was quite black.

June 16th.—A man was killed at Saddleworth, there were no marks on the body.

June 17th.—At Swinefleet a man and the horse on which he was riding were killed; from the following statement it is evident that some marks must have been found:—"From an examination of the body it appears that the lightning passed in at the man's head and out at his knee."

August 12th.—At WOOTTON, near BEDFORD, a man was killed; a hole 4 inches in diameter was cut in his hat, but there were no marks on the body.

August 12th.—Near Matlock a man was killed. The clergyman wrote that "such was the effect of the fluid that he was buried before an inquest could be held."

1859. May 31st.—SHORE, near LITTLEBOROUGH, a man was killed; there was no discoloration, but one leg was broken. (As he was over 60 years of age, it is possible that this may have arisen from his falling to the ground.) Fornham, a man was killed; he had a mark on his forehead.

July 23rd.—LANISHEN, CHEPSTOW, man and boy killed. The man was but slightly burnt, but the body of the boy was reduced to a cinder. At the inquest Dr. Audland stated that he had never heard of a body being charred as that of the boy.

Part II.—*In cases of Injury.*

1858. June 3rd.—WIBSEY. Two boy swere sitting on a form together; one was struck on the right shoulder, the other on the left. The fluid went across the back of the former, burning him all the way.

1859. July 2nd.—SHEPPEY. A Coast Guardsman who was much injured must, I imagine, have been marked, as the course of the lightning is thus fully detailed:—"It struck the left side of his neck, passed down his watch chain into his fob, thence down both thighs and across the right knee down to his feet."

July 19th.—BRAMHOPE. A young woman was rendered insensible; her father writes:—"It had gone from her neck down the front part of her body, and left the very mark thereon." Knaresborough. A lady thus describes the injury done to herself and her son:—"My son's hair was singed, and across the shoulders he had marks as if he had been beaten. . . . . My own arm and side were turned quite black, it had the appearance of a very severe bruise, but felt more like a burn."

KIND OF TREES STRUCK.

List of trees reported to have been struck.

Trees.	1857.	1858.	1859.	Total.
Ash	1	1	0	2
Crab	0	0	1	1
Elm	0	0	5	5
Lime	1	0	0	1
Oak	1	0	2	3
Poplar	0	1	1	2
Willow	0	0	1	1
Totals	3	2	10	15

In 15 cases the class of tree struck has been mentioned: of these one-third were elms, the next in order of this unenviable distinction are the oak, ash, and poplar; instances also occurred of the crab, the lime, and the willow being injured by the lightning.

It is satisfactory to find that as far as so short a series is adequate, it corroborates previous opinions on the subject. I may perhaps be permitted to quote one of the earliest with which I am acquainted. In the year 1787, Mr. Hugh Maxwell wrote to the American Academy that he thought he might state from his own experience that the elm, chesnut, oak and pine are *often*, ash *rarely*, and beech, birch and maple *never* struck.

A communication with which I have been favoured by Mr. Ingram, of Belvoir Castle, bears closely on this subject, and is, I think, worthy of consideration. He says:—"I filed your letter, resolving to keep a sharp look out in my rides about the neighbourhood for all the thunder blasted trees. It is of course difficult to obtain perfectly accurate information, because trees are taken away after their destruction, but I have ascertained that within the area of Croxton Park, 20 per cent. of the trees (oaks) have been struck with lightning. The Park is situated on high ground, the substratum is rock (limestone) which has more or less iron in it. The oaks, where the soil is strongly ferruginous, are useless as timber trees; the wood when sawn splits and rives in every direction, possibly from the quantity of iron."

DISCUSSION.

THE PRESIDENT (Dr. Marcet) said that the result of Mr. Symons's investigation showed the greater prevalence of thunderstorms in the summer months as compared with the winter months. This was possibly due to the larger amount of evaporation from the sea-surface during the hot months of the year. It was well known that the sea, considered electrically, was positive, and therefore during the summer months the large amount of vapour rising from the sea-surface caused an accumulation of positive electricity in the atmosphere, which gave rise to thunderstorms. It was rather curious that the number of men killed by

lightning was so greatly in excess of that of women; but this was no doubt due to men being more exposed to this danger, by reason of their out-door occupations. The number of human beings killed seemed very large. The number of houses struck was remarkable, and tended to show that means of protection from lightning were not largely made use of thirty years ago. The number of trees struck appeared large, but the damage to telegraphic apparatus, considering the large amount in use throughout the country, seemed extremely small. He himself remembered witnessing the phenomenon of ball lightning some years ago when driving in the neighbourhood of Esher in a thunderstorm. He and his companion saw a ball of fire on the top of a hedge, 30 or 40 yards from them, where it remained stationary for a few seconds and then vanished.

Mr. M. JACKSON inquired whether Mr. Symons had ever heard of a railway station being damaged by lightning. He had been told that a railway station was one of the safest places to be in while a thunderstorm was in progress.

Mr. MARRIOTT stated that more than 1000 thunderstorm reports had been received in connection with the investigation which the Royal Meteorological Society was making into the question of British thunderstorms, as many as 60 returns for one day having in several cases been sent in. The thunderstorms of 1888 had not been like the ordinary summer thunderstorms, occurring at the break-up of spells of hot weather, but had been of a totally different type. In winter the thunderstorms were usually associated with the passage of depressions along the north-western coasts of the British Islands. Regarding damage to trees by lightning, the Rev. O. P. Cambridge had written an elaborate account of damage done at Bloxworth to no less than eight trees whose greatest distance apart was 70 yards, the whole damage appeared to have been done by one upward stroke.[1] In May last there was a correspondence in the *Times* respecting injury to sheep and cattle, and the general conclusion arrived at was that the congregation of the animals closely together caused a great deal of heated air to arise, which served to attract the lightning. The disruptive force of lightning was well illustrated in the instances in which men who had been struck had their clothes torn into ribbons, and their boots shattered. He exhibited a photograph which he had taken of the clothes of the two men (sawyers) who were struck and injured by lightning at Spaniard's Farm, Hampstead Heath, on June 14th, 1888.

Captain MACLEAR said that he believed the reddish hue of lightning to be due to the discharge taking place through falling rain, and the bluish tint to the discharge through dry air, and this would fall in with the report that when damage was sustained the flash seen was generally blue, and with the popular notion that lightning was harmless when rain had begun to fall. There is one particular class of thunderstorm he had never seen described in books on Meteorology, in which the form of lightning approached nearer to sheet than to forked, and resembled very much the brush discharge; it occurred when the clouds were very low and in great masses, from which there was a heavy rainfall: in this storm the red colour predominated. He had produced something very like the effect of this lightning by passing the electric current from an induction coil through cotton wool wetted and slightly parted to represent clouds.

Mr. ARCHIBALD said that the theories as to the formation and discharge of atmospheric electricity were so numerous and varied that it was difficult at present to decide between them. Thunderstorms were certainly more numerous in summer, but there was a class of thunderstorms occurring in winter in the British Islands which were associated with cyclonic disturbances. In Eastern Bengal, where he had lived for some time, thunderstorms were of extremely common occurrence in certain months, and of a severe character. Anyone who had experienced a "North-wester" in Bengal would not soon forget it. He had, however, never heard of any case of injury to human beings by lightning in tropical thunderstorms, and this seemed to point to the supposition that the storms were at such an altitude that the lightning strokes did not reach the earth. Lightning conductors were seldom erected in India. It would be interesting if the table of the number of persons killed was made to show the monthly figures. The colour of lightning, as he had seen it in India, was invariably blue, like that of the electric spark. He remembered on one evening sitting out on the verandah of his residence at Patna and watching the lightning continuously

[1] A plan of the position of these trees was exhibited.

flashing across his zenith in all directions in the sky for two or three hours ; and during the whole of that time he did not hear a single peal of thunder. This was possibly due to the storm being so high in the atmosphere that the thunder was inaudible. In the district of Tunbridge Wells, where he now lived, he had noticed that oak trees were the most common objects damaged by lightning. In Assam gum trees were the object most commonly struck. He thought it would be well in any future investigation of thunderstorms not to confine the inquiry to this country, but to include tropical storms as well. He considered that the phonograph might be used to record thunder. We already *photo*graph the lightning, and he did not see why it would not be quite as easy to *phono*graph the thunder.

Mr. B. WOODD SMITH exhibited two photographs of one of the men injured at Hampstead, referred to by Mr. Marriott, showing the course taken by the lightning. The man was standing under an oak, leaning against the tree, when the lightning struck his shoulder and passed down his side, as shown, to his feet, rendering him unconscious. Thence (possibly conducted by a long saw which they had been using in a saw pit adjoining, and had taken under the tree with them), it crossed to the knees of the other man and passed down to his feet. With reference to the sensation of being "pressed down," he (Mr. Smith) quoted the case of a friend who was in a boat with three other persons in Scarborough Bay when the boat was struck, and one of the occupants killed, the others being rendered unconscious. All that this friend remembered was that the boat seemed to be violently forced down into the sea.

Mr. SOUTHALL said that he once saw a ball of fire fall during a thunderstorm about 40 years ago. He remembered two or three of the thunderstorms in the period of 1857-59, during one of which (August 13th, 1858) 2·75 ins. of rain fell in 50 minutes. These years were very hot, and the thunderstorms were very violent. So far as his own observations went, he believed that oaks were the trees most frequently struck by lightning, Lombardy poplars coming next.

Dr. WILLIAMS described a curious sensation experienced by himself and two others during a thunderstorm on one of the Swiss mountains. He and a lady, together with a guide, had ascended a moderately high mountain, the Pic d' Arzinol (9,849 ft.), while a thunderstorm was raging on a mountain to the northward of them. Immediately to the eastward was the magnificent snow-clad peak of the Weisshorn illumined by sunshine, which they were so occupied in admiring that they did not notice the approach of the thundercloud, until presently they each in turn experienced a strange buzzing sensation in the hair of their heads. At first they did not recognise the origin of the buzzing, but when they did so, were somewhat alarmed, and commenced to descend, and when about 30 yards lower the peculiar sensation entirely ceased, they evidently having passed beyond the influence of the electrified atmosphere at the higher level, were no longer acting as points for the conduction of the electrical current.

Mr. LAWSON said he had spent five years at Sierra Leone, where thunderstorms are very frequent and violent at the commencement and end of the rainy season. During that period he only remembered two instances of houses being struck by lightning in Freetown, in one of which a man was killed. The officers' barrack on Town Hill, three-quarters of a mile from the river and 400 feet above it, was struck on one occasion, but, owing to the extensive metallic communications from the ridge to the ground, there was no injury to the building, and no one was hurt. On another occasion the flag-staff at Fort Thornton, lower down the hill, was shivered; and, on a subsequent one, the conductor at the magazine at the same place was struck as he was passing the gate of its enclosure, and within 30 yards of it. It would appear that injuries from lightning at any given point are not necessarily proportional to its frequency there, but must depend on some other factor; in the higher districts of South Africa, for instance, where the climate is drier and vegetation more scanty, though thunderstorms are much fewer, accidents from lightning are more common than at Sierra Leone, where the opposite conditions prevail.

Mr. HARRIES called attention to the colours of lightning, remarking that, with the exception of London and one or two other stations, the observers invariably noted only one colour during a storm. This renders the table of relative frequency quite unreliable, there being no resemblance between it and the one given in the *Meteorologische Zeitschrift* for November 1888, p. 447, in which

Herr Krebs gives the results of his observations during a thunderstorm in its passage towards Altona on the night of August 12th-13th, 1888. Standing at the open window of a dark room, he registered 47 flashes of lightning as follows:—

Flashes.	White.	Red.	Red Yellow (Orange).	Red and Blue (Violet).	Red & Green.	Green.	Blue Green.	Green Yellow.	Doubtful.
First 10 flashes..	..	3	1	1	1	..	1	1	2
Second 10 „ ..	..	4	..	2	1	2	1	..	..
Third 10 „ ..	1	8	..	..	..	..	1	..	2
Fourth 10 „ ..	..	6	1	..	..	..	..	..	1
Last 7 „ ..	..	3	2	1	..	..	..	..	1
Totals	1	24	4	4	2	2	3	1	6

It will be seen that the number of red flashes increased considerably in the second half of the storm, Herr Krebs attributing this partly to the action of atmospheric absorption and the increasing distance of the lightning. Allowing for the doubtful observations, the red flashes formed three-fifths of the whole, and were six times as numerous as any other colour, there being only one white flash. The observations tabulated by Mr. Symons place red second on the list, with a quarter of the total number.

Mr. MAXWELL HALL said that he had had considerable experience of thunderstorms in the mountains of Jamaica, and he did not think there was a better part of the world for their study. He could not agree with the suggestion made by Mr. Archibald that in the Tropics lightning did not reach the ground, although it was perfectly true that in the Tropics very few accidents occur to life and buildings, and he believed that in the case of Jamaica, at least, this immunity from damage by lightning was due to the large number of trees, the numerous forests, and the usually heavy rains which precede the thunderstorms. The intensity of the lightning flashes was very great, and the interval between the flash and the peal of thunder was often as much as 80 seconds, equivalent to a distance of 16 miles between the flash and the observer. The flashes were not single, and the impression left after observing a flash was that a very large number of sparks had passed in succession in the same zigzag path. The rain that accompanied these storms was considerable, usually at the rate of about half-an-inch in half-an-hour, but it was sometimes much heavier. The air temperature decreased greatly during the passage of a storm, sinking from, say, about 85° down to 65°; this was of course due to the cold air brought down by the rain. Hail seldom fell; but there was a sound in the air when rain commenced to fall from high clouds vertically above the observer very much resembling the sound of a railway train passing at a distance of about half-a-mile. It was curious that the trees on some hill-sides were more frequently struck than on others, and on his own property one part of a particular valley was nearly denuded of trees by reason of the frequent lightning strokes with which it had been visited. There was a gate-post of masonry too, situated under a tree, which had been struck repeatedly, and the stones slightly displaced each time. Cocoa-nut trees in exposed positions were often struck, and whenever this was the case they were invariably killed. The copper rod which protected his premises had been repeatedly "struck" by lightning, and on such occasions a slight report was heard similar to the sharp crack of a whip, followed by subdued thunder; thunder was loudest when the lightning made earth about a quarter of a mile from the observer. The colour of the lightning seen in Jamaica was usually blue; it was sometimes red, but blue predominated. The sunlight was so intense in the Tropics that the lightning sometimes could hardly be seen, as, for instance, when the flashes proceeded from the advancing edge of clouds moving across the otherwise clear sky; this, he believed, was the explanation of so-called invisible lightning.

Mr. SYMONS, in reply, said that the large number of persons killed by lightning was perhaps due to the fact that almost every accident or case of fatal injury

to human beings was duly reported in the newspapers, whereas damage to buildings, cattle, &c., was not always considered of sufficient importance to place on record. It would be very interesting if somebody would extract from the Registrar General's Returns, which now extended over 50 years, the numbers of deaths attributed to lightning. The comparatively small amount of damage to telegraph apparatus was perhaps partly due to the fact that the fusion of telegraph wires, &c., was not deemed of sufficient importance to be always reported, and also it must be remembered that the amount of telegraphic apparatus in use in the country 30 years ago was much less than that at the present day. He recollected one case of a railway station being struck by lightning. It was recorded by the late M. Melsens, and occurred at Antwerp. He was glad to know that the thunderstorms of the past summer had been of an exceptional character, as he had been somewhat puzzled to account for the complete absence from his self-recording barometer of traces of those extremely sharp oscillations usually registered during the passage of thunderstorms. There seemed little doubt that the large number of sheep killed by a stroke of lightning was due to the aggregation of the animals together. There was a case in America of great loss of life at a fair or large gathering of people under a canvas tent which was struck by lightning; the heated air arising from such a large concourse of people possibly affording a path for the lightning, and their being so closely packed resulted in a great loss of life. It was well known that if a man was thoroughly wet it was impossible for the lightning to kill him, and Faraday had shown that it was impossible, with all the electrical apparatus at his disposal, to kill a rat whose coat was saturated with water. Regarding Mr. Hall's remarks respecting the form of lightning, he was of opinion that if our eyes were sufficiently trained to follow the flashes of forked lightning we should see them as a succession of dots or sparks of light. It was difficult to account for the large amount of damage done by lightning in some districts compared with others. For instance, Yorkshire was a county in which a large amount of damage had been done by lightning strokes. Whether this was due to the nature of the soil or any other local peculiarity he could not say. It was notorious too that lightning frequently had a marked partiality for certain objects, and numerous instances were given in the *Report of the Lightning Rod Conference* of the same buildings being struck over and over again, *e.g.* p. 161, where it is mentioned that Rouen Cathedral was struck in 1110, 1117, 1284, 1351, 1625, 1627, 1642, 1768 and 1822.

NOTES ON THE

MEETING OF THE INTERNATIONAL METEOROLOGICAL COMMITTEE

AT ZURICH IN SEPTEMBER 1888.

By ROBERT H. SCOTT, M.A., F.R.S., Foreign Secretary.

[Received October 24th.—Read November 21st, 1888.]

The International Meteorological Committee was appointed by the Congress of Rome in 1879, and it received instructions *inter alia* to arrange for the convening of another Congress within the space of five years.

At the successive Meetings of the Committee, at Berne in 1880, Copenhagen 1883, and Paris 1885, the subject of this contemplated Congress was

brought forward, and on each occasion the opinion was expressed that the time had not arrived for such a meeting.

Meanwhile a number of questions had been proposed by members of the Committee and others, which were considered by the Committee to lie outside the commission it had received at Rome. Among the most important of these questions was that of the possible augmentation of the number of the Committee by the co-option of new members. This, however, had been answered on each occasion in the negative, for the simple reason that the number 9 having been fixed at Rome, it would be impossible to limit any increase of the body without giving serious offence. Some of the applications for admission to the Committee came from countries which had done little or nothing for our science.

This was the state of affairs when at Easter last a proposal was made by the French authorities to invite a Congress to meet in Paris in 1889, on the occasion of the International Exhibition to be held in that year. This suggestion was circulated among the members of the Committee, but it did not meet with approval, and accordingly it was determined to hold a meeting of the Committee in the course of the summer of 1888, in order to discuss the question of its own further continuance.

The meeting was held at Zurich, commencing on September 3rd. Accommodation was provided for it by the Swiss Authorities in the Polytechnic Institution, and it was attended by the full Committee.

The discussions were practically confined to three subjects—

1. The conditions to be laid down for the publication of data by travellers, &c., so as to ensure their being useful for the advancement of sound climatological knowledge.

2. The proposals for Cloud Nomenclature which were laid before this Society in February 1887 by Mr. Abercromby and Dr. Hildebrandsson.[1]

3. The position of the Committee itself.

As regards No. 1, which may be considered to have taken its rise from the proposals of the Observatory of Rio Janeiro to publish a Climatological Dictionary, certain rules were laid down which will commend themselves to every person who has ever undertaken any climatological inquiry of any character. They are as follows:—

The Committee was of opinion that, in view of the considerable number of reports of Meteorology and Climatology published by travellers and geographers, it would be well to lay down the following rules for printing meteorological means, &c., especially those which might be useful for meteorological researches:—

1. It should be stated what instruments have been used for observing, and also their corrections, if known, and the method of exposure. The height of the barometer above sea-level should be given, at least with the greatest possible exactitude.

2. Precise information should always be given as to the methods employed for the calculation of means (on the hours of observation and the formulæ used for reductions).

It is further desirable to give the means for the different hours of observation (*e.g.* for temperature, humidity, and atmospheric pressure), to facilitate the reduction to true means, which may be undertaken later on.

3. In publishing the means for several years, it is very desirable to print the

[1] *Quarterly Journal*, Vol. XIII. pp. 148 and 164.

separate means for periods of five years (lustra), in accordance with the resolution of the Congress of Vienna (commencing with the first year of each pentade: —1881-5, 1886-90, &c.).

In this way it would be possible to obtain, with the greatest facility, simultaneous and corresponding mean values, which are indispensable for serious investigations on the distribution of meteorological elements, especially with regard to temperature and atmospheric pressure.

The Executive Officers were earnestly requested to publish these rules as soon as possible, and in different languages.

As regards No. 2. The Committee was of opinion that the proposals made by the authors of the papers on cloud classification above-mentioned did not commend themselves for immediate adoption, and suggested that the subject should be further studied.

As to subject No. 3,—the position of the Committee,—it was resolved after mature discussion, to perform the operation of the "Happy Despatch," and the Committee, therefore, dissolved itself by the following resolution:—

The Committee, considering that the convening of an International Congress with the character of the preceding Congresses of Vienna and Rome presents great difficulties, feels that its mission is ended, and that it ought to dissolve itself.

Nevertheless, to continue the relations which have been so fruitful for some years past among the different meteorological systems, the Committee nominates Executive Officers, who will be charged with taking steps for convening at a suitable time an international meeting of the representatives of the various meteorological services.

The Committee requests its Executive Officers, viz. Mr. Wild (President) and Mr. Scott (Secretary) to accept the position indicated for the new office in the preceding resolution.

According to this resolution, Professor Wild and myself are the sole survivors of the Committee, and we are instructed to arrange for a meeting in 1890 if possible.

On the completion of the business, I visited the Säntis Observatory, at the height of 8,215 feet, on the invitation of the Swiss Meteorological Commission. The other members of our Committee who joined our party were Hofrath Dr. Hann and Professor Mohn.

We went by train to Appenzell, thence three miles by omnibus to the Baths of Weissbad, where we slept, and thence had a seven hours' walk to the summit. The ascent was not particularly fatiguing, and much of the descent was carried out by glissade on the snow slope. The Observatory is on the very summit, which is situated several miles from any considerable mass of at all equal elevation, so that the position is very isolated. The observations are conducted by a single observer, and his only companions are the porter and his wife, the former being a muscular mountaineer, who carries up every thing used in the establishment, and is also able to take the readings on a pinch.

I hear that on the Sonnblick, in the Austrian Alps, the observer is even more completely cut off from intercourse with his fellow-men. The approach to his hermitage is not by a rock path, like that to the Säntis is, at least in summer, but involves a walk at all seasons of at least an hour across a glacier.

ON A METHOD OF PHOTOGRAPHING CIRRUS CLOUDS.

By Dr. A. RIGGENBACH.

(Communicated by R. H. Scott, M.A., F.R.S., Foreign Secretary.)

[Received November 19th.—Read November 21st, 1888.]

Great difficulty is experienced in obtaining photographs of cirrus clouds, owing to the fact that the blue light of the sky acts with nearly the same actinic energy as the white light of the clouds on the sensitive silver salts of the plate.

If any plan could be devised for dulling this blue light of the sky while the light of the clouds was left unaffected, the clouds would stand out from the comparatively dark background of the sky in the photographic picture, just as they do in the images formed by our eyes.

The analyser of any polarising apparatus will effect this object. The light from the blue sky is partly polarised, and to the largest extent at the points which are situated 90° from the sun; the plane of polarisation passing through the points looked at, the sun, and the eye of the observer. On the other hand, the light coming from a cloud is only polarised to a slight extent.

Let us now take a Nicol's prism, and look at a cloud situated 90° from the sun. We know that such a prism will allow no light to pass, of which the plane of polarisation does not contain the longer diagonal of the terminal face of the prism.

Now, if we turn this longer diagonal of the prism towards the sun the cloud will appear, as it does to the eye, bright in a bright sky. If now the Nicol prism be turned through 90°, so that its shorter diagonal points to the sun, the sky light will be darkened in a very striking manner, and all the filaments of the cloud will come out with greatly enhanced sharpness.

For a Nicol's prism we may substitute a dark mirror, or painter's mirror, or, best of all, a plate of obsidian. If such a plate be held so that the plane which passes through the cloud, its reflected image and the eye, is normal to the line from the observer to the sun, the mirror extinguishes the polarised light from the sky almost completely, and the reflected image of the cloud comes out sharp on a dark background. If, then, such an obsidian plate be fixed before the lens of a photographic camera, so that its plane is inclined at an angle of 33° to the optical axis of the lens, and the camera be placed so that the sun's rays shine perpendicularly on one of its sides, we then turn the whole apparatus round the direction in which the sun lies, as an axis, until a cirrus cloud is visible in the camera. If now a sensitised plate be inserted, a picture of the cloud can be produced under the most favourable conditions possible.

A still simpler mode of obtaining such cloud pictures is to use the surface of a lake as a polarising mirror. The best clouds for such a purpose are those at sunrise or sunset, at an altitude of about 37°, and in an azimuth either greater or less than that of the sun by 90°.

I have the pleasure of exhibiting to the Royal Meteorological Society a photograph taken in August 1888, soon after sunrise, on the Lake of Sarnen, looking southwards. Dr. Burckhardt, who took the photograph, has kindly allowed me to use the picture.

The clouds are especially clear in the reflection; but the coast lines also come out with unusual distinctness, much clearer than in the direct view, owing to the extinction of the sky light.

NOTE ON THE

PROLONGED SPELL OF COLD WEATHER from SEPTEMBER 1887 to OCTOBER 1888.

By CHARLES HARDING, F.R.Met.Soc.

[Read December 19th, 1888.]

At the meeting of the Society held in June of the present year, I communicated a paper on "The Cold Period from September 1887 to May 1888."[1] The spell of cold was, however, protracted till long after the period then dealt with, continuing indeed throughout the whole of the following summer, and embracing also a very large portion of the recent autumn. The persistent continuance of the cold weather was so exceptional, that probably the present "Note," which forms really an Appendix to my former paper, will not be without interest to the Society.

The former paper contained a brief history of the weather for the several months, September 1887 to May 1888, and the following will give similar details for each month from June to October 1888.

June was cold and unseasonable throughout, with the exception of one or two isolated days, and the mean for the month, considering the British Islands as a whole, was about a degree below the means for the corresponding period in either 1879 or 1886, which were abnormally cold. At the commencement of the month a good deal of snow fell in parts of Scotland, and exceptionally low temperatures for June were experienced in the northern parts of the country, the shade thermometers falling below the freezing

[1] *Quarterly Journal*, Vol. XIV. p. 270.

point. In London the temperature on four consecutive days, from the 17th to 20th, did not exceed 55°, whereas in the previous six years there were in all during June only two days on which this temperature was not reached. The type of weather during the month was cyclonic, and very favourable to the development of thunderstorms, which were experienced with more than usual frequency, and the numerous disturbances which reached this country from off the Atlantic caused much cloud and heavy rain.

JULY was dull, cold and wet over the entire Kingdom. Not a single day of really summer weather was experienced throughout the month, and ground frosts occurred nearly everywhere. Falls of snow were reported on the 11th from places widely separated, and from as far south as the Isle of Wight, whilst at the close of the month large tracts of land in different parts of England were under water, and parts of London were suffering materially from flood caused by the excessive rains. In London the mean temperature for the month was 59°, which is 4° below the average and 7° below the mean for July in 1887. The defect of temperature was due to the very low day readings, the mean maxima being 12° below those of 1887, whilst the minima or night temperatures were only 3° colder. The absolute maximum at Greenwich was 74°, and the records from 1841 fail to show a July without a higher temperature. In the southern suburbs of London the thermometer did not exceed 72° throughout the month. The observations for the last 75 years only give two instances of so low a daily mean as that recorded on the 11th, and there is no similar instance on record of two consecutive days as cold as the 11th and 12th, the mean being 49°, which is colder than the two days ending March 10th, and colder by 4° than the mean for the three days, December 4th to 6th, 1888. At Greenwich the total rainfall for the month was 7·09 ins., which is 1·20 in. in excess of the largest previous fall on record for the corresponding month. At Berkhamsted, in Hertfordshire, well clear from the London smoke, the average sunshine for each day in July was 2 hours 40 minutes, the sun being above the horizon for about 16 hours.

AUGUST was dull and cheerless, almost without interruption throughout the month, and the mean temperature was 2° or 3° below the average over the whole of the United Kingdom. Heavy thunderstorms occurred at the commencement of the month, and at Ingatestone, in Essex, the rainfall for the 24 hours ending 9 a.m. on the 2nd was 3·20 ins. Warm weather was experienced from the 7th to 10th, which were the only four days of seasonable weather experienced during the month.

SEPTEMBER was generally bright and dry, but yet the temperature for the month was everywhere below the average, the deficiency ranging from 1° in the East of Scotland and in the South of England to 3° in the Midland Counties and in the North-west of England.

OCTOBER commenced with very cold and unsettled weather, sleet and snow falling at many of the northern stations. The mean temperature for the week ending the 8th was as much as 12° below the average in the East of England and 11° in the Midland Counties and in the South of England; whilst in Scotland and Ireland, which were the warmest parts of the kingdom,

the temperature was 6° or 7° below the average. In London the shade thermometer fell to the freezing point or below on six consecutive nights, from the 5th to 10th, a spell of cold altogether without precedent so early in the month. The Greenwich observations from 1841 only show four years with frost during the first ten days of the month; these occurred respectively in 1849, 1853, 1867, and 1877, and there is no previous instance of more than two consecutive frosty nights so early in the month. Warm weather set in towards the close of the month, but the mean temperature was below the average over the whole of England, the deficiency ranging from 1° to 5°.

Table I. shows the number of degrees of excess or defect of temperature for each week, and is in continuation of a similar Table given in the former paper, the values being thus shown for each of the 59 weeks and for each of the 12 districts into which the United Kingdom is divided. In this Table, as well as in the one given with the former paper, the deficiency of temperature very largely prevails over the excess.

TABLE I.

DIFFERENCE OF MEAN TEMPERATURE FOR EACH WEEK FROM THE AVERAGE OF 20 YEARS, 1861–1880.

Week ending	Scotland, North.	Scotland, East.	England, North-East.	England, East.	Midland Counties.	England, South.	Scotland, West.	England, North-West.	England, South-West.	Ireland, North.	Ireland, South.	Channel Islands.
1888.	°	°	°	°	°	°	°	°	°	°	°	°
May 21	+2	+3	+3	+ 3	+ 2	+ 2	+2	+2	−1	0	0	−1
28	−2	−2	−4	− 4	− 2	− 2	−2	0	0	+2	+2	−1
June 4	−7	−7	−3	+ 2	0	+ 1	−5	−4	0	−4	0	0
11	−3	−4	−3	− 1	− 2	− 2	−2	−3	−2	−3	−2	−1
18	−2	−1	−4	− 5	− 6	− 5	−2	−4	−4	−3	−2	−3
25	−2	−3	−6	− 3	− 3	− 1	+2	−1	−1	+1	+1	−2
July 2	−1	−3	−5	− 4	− 3	− 3	0	−2	−3	−2	−1	−2
9	−6	−6	−6	− 5	− 5	− 4	−4	−5	−3	−4	−3	−2
16	−4	−4	−8	− 7	− 7	− 6	−4	−6	−5	−5	−4	−5
23	0	−1	−1	− 2	− 1	− 2	+1	−1	−2	−1	−2	−3
30	−4	−4	−4	− 4	− 5	− 2	−2	−4	−4	−4	−3	−2
Aug. 6	−4	−5	−6	− 7	− 6	− 5	−5	−6	−5	−5	−4	−4
13	−2	0	+1	+ 3	+ 2	+ 2	0	0	0	−1	+1	0
20	−5	−5	−6	− 8	− 7	− 6	−4	−6	−6	−3	−4	−3
27	+2	+2	+1	− 1	− 1	− 1	+2	−1	0	+1	+1	0
Sept. 3	−1	−1	−2	− 4	− 5	− 3	−2	−3	−4	−3	−2	−2
10	−3	−3	−2	− 3	− 4	− 3	−2	−3	−4	−3	−3	−3
17	+1	+1	−1	− 1	− 2	− 1	0	−1	−1	0	−2	−1
24	+3	+2	−2	+ 1	− 1	+ 2	−1	−1	0	−1	−3	+1
Oct. 1	−6	−5	−4	− 3	− 3	− 1	−4	−4	−1	−2	−1	−1
8	−7	−6	−9	−12	−11	−11	−7	−9	−9	−6	−7	−7
15	−2	+1	−2	− 5	− 5	− 6	−2	−3	−5	−2	−4	−4
22	+2	+3	−1	− 5	− 4	− 3	+2	−1	−1	+2	+2	−2

From this Table, and the companion Table in my former paper, it will be seen that in the South-west of England there was not a single warm week between March 12th and October 22nd, a period of 32 weeks, and during the same period there was only one warm week in the North-west of England and the Channel Islands. There were but four warm weeks during the whole

period of 14 months in the North-west of England, and only 5 and 6 warm weeks respectively in the South-west of England and in the Channel Islands. There was no part of England or Ireland with more than ten warm weeks, and there were not more than six weeks in which warm weather was at all general over the United Kingdom.

The records of effective and non-effective temperature for vegetable growth which are given by the Meteorological Office in the *Weekly Weather Report* afford a very easy means of obtaining the accumulative temperature for any long period, and the result obtained by algebraically adding the day-degrees above and below 42° give a standard of comparison which is readily convertible to actual mean temperature. In my former paper a similar table to the following was given for a period of 86 weeks, but this has been recast, so as to embody the additional period here dealt with.

In Table II. each difference of 400 day-degrees for the period represents about 1° in the difference of mean temperature. For example, in the South of England the difference between 8829 in 1883-4 and 2183 in 1887-8 is 1646, or a difference of 4° in the mean temperature of the entire period.

TABLE II.

RESULTANT DAY-DEGREES ABOVE 42° FAHRENHEIT FOR 59 WEEKS FROM THE COMMENCEMENT OF SEPTEMBER TO ABOUT THE THIRD WEEK OF OCTOBER IN THE FOLLOWING YEAR DURING THE 10 YEARS, 1878–88.

Years.	Scotland, North.	Scotland, East.	England, North East.	England, East.	Midland Counties.	England, South.	Scotland, West.	England, North-West.	England, South-West.	Ireland, North.	Ireland, South.	Channel Islands.	Mean British Islands generally.
1878–79	833	1095	1469	1914	1810	2376	1625	1822	2970	2838	2514	3597	2072
1879–80	1841	2220	2265	2557	2516	3100	2628	2726	3735	2803	3440	3890	2810
1880–81	689	1253	1786	2378	2204	2962	1722	2170	3203	2097	2812	4022	2275
1881–82	2105	2610	2788	3071	2986	3593	2878	3053	3635	2906	3528	4354	3126
1882–83	1410	1833	2237	2646	2513	3275	2274	2588	3184	2290	2876	3928	2588
1883–84	1728	2430	2827	3326	3212	3829	2846	3145	3781	2952	3624	4479	3182
1884–85	1221	1868	2309	2601	2506	3222	2090	2415	3029	2359	2877	3733	2519
1885–86	1073	1641	1990	2444	2366	3044	1888	2232	2928	2241	2866	3909	2385
1886–87	1490	2000	2177	2445	2361	2971	2288	2469	3094	2667	3234	4077	2606
1887–88	672	1044	1349	1747	1572	2183	1591	1797	2267	1971	2472	3324	1832
Mean	1306	1799	2120	2513	2405	3056	2183	2442	3183	2512	3024	3931	2540
	Departure from Mean of 10 years, 1878–9 to 1887–8.												
1878–79	−473	−704	−651	−599	−595	−680	−558	−620	−213	+326	−510	−334	−468
1879–80	+535	+421	+145	+ 44	+111	+ 44	+445	+284	+552	+291	+416	− 41	+270
1880–81	−617	−546	−334	−135	−201	− 94	−461	−272	+ 20	−415	−212	+ 91	−265
1881–82	+799	+811	+668	+558	+581	+537	+695	+611	+452	+394	+504	+423	+586
1882–83	+104	+ 34	+117	+133	+108	+219	+ 91	+146	+ 1	−222	−148	− 3	+ 48
1883–84	+422	+631	+707	+813	+807	+773	+663	+703	+598	+440	+600	+548	+642
1884–85	− 85	+ 69	+189	+ 88	+101	+166	− 93	− 27	−154	−153	−147	−198	− 21
1885–86	−233	−158	−130	− 69	− 39	− 12	−295	−210	−255	−271	−158	− 22	−155
1886–87	+184	+201	+ 57	− 68	− 44	− 85	+105	+ 27	− 89	+155	+210	+146	+ 66
1887–88	−534	−755	−771	−766	−833	−873	−592	−645	−916	−541	−552	−607	−708

The data for this comparison are only available for 10 years, and it will be seen that the cold period which ended last October is very considerably in excess, that is, the day-degrees above 42° are in defect of any previous similar period; and this is peculiar to all districts with the single exception of Scotland North.

In Table II. there is necessarily a certain amount of overlapping in the formation of each period, the results from September to the third week in October being repeated in each successive grouping; for the object in view this, however, does not in any way vitiate the conclusions arrived at.

In the following comparison the duplication of observations has, however, been avoided, and the results are worked for the complete years only.

TABLE III.

MEAN TEMPERATURE FOR THE 12 MONTHS ENDING SEPTEMBER FOR EACH OF THE 22 YEARS 1867 TO 1888.

Year ending September.	Scotland, North.	Scotland, East.	England, North-East.	England, East.	Midland Counties.	England, South.	Scotland, West.	England, North-West.	England, South-West.	Ireland, North.	Ireland, South.	Channel Islands.	Mean British Islands generally.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1867	47·9	46·8	46·6	49·1	48·7	49·5	48·0	48·7	51·3	48·8	49·8	..	48·7
1868	47·3	48·9	48·6	50·0	50·7	50·6	49·4	50·0	52·2	49·6	51·2	..	49·9
1869	46·0	47·3	47·6	49·3	49·4	49·9	48·5	48·9	52·0	49·4	50·7	..	49·0
1870	46·0	47·4	46·9	48·1	49·0	48·9	47·9	48·7	51·0	49·3	50·2	..	48·5
1871	45·7	45·9	46·1	47·6	48·2	48·4	47·2	47·7	50·5	48·2	49·6	..	47·7
1872	46·3	47·2	47·4	48·9	49·0	49·4	48·3	49·1	51·0	48·5	50·0	..	48·6
1873	45·9	46·7	47·1	48·1	48·4	49·1	48·0	48·3	50·5	47·8	49·1	..	48·1
1874	47·0	47·8	48·3	49·0	49·3	49·9	48·9	49·2	51·6	48·9	51·2	..	49·2
1875	46·3	46·8	47·2	48·1	48·3	49·1	47·6	48·3	50·7	48·5	50·9	..	48·3
1876	46·0	46·6	47·4	48·3	48·5	49·0	47·6	48·2	50·4	47·5	50·2	..	48·2
1877	45·4	46·2	47·4	49·2	48·9	50·1	47·4	48·4	51·1	47·9	50·7	..	48·4
1878	46·6	48·1	48·8	49·8	50·1	50·7	49·5	50·1	52·1	49·6	51·7	..	48·8
1879	43·4	43·7	44·9	46·1	46·0	47·2	45·3	45·8	48·2	45·8	47·7	49·8	46·2
1880	46·5	47·1	47·2	47·8	47·7	49·0	48·2	48·2	50·6	48·6	50·3	50·8	48·5
1881	43·1	45·2	46·0	47·7	47·3	49·1	45·8	47·1	49·4	47·0	48·5	50·9	47·3
1882	46·7	48·0	48·5	49·1	48·8	50·3	48·7	49·2	50·6	49·1	50·3	51·7	49·3
1883	45·1	46·2	47·4	47·8	48·0	49·7	47·1	48·1	49·5	47·5	48·9	51·5	48·1
1884	46·1	47·8	48·7	49·9	49·6	51·1	48·8	49·4	50·7	49·0	50·5	52·6	49·5
1885	45·1	46·1	47·1	47·8	47·6	49·4	46·6	47·3	49·0	47·3	48·6	51·0	47·7
1886	44·0	45·4	46·2	47·2	47·0	48·6	46·0	46·7	48·5	46·9	48·5	50·9	47·2
1887	46·0	47·3	46·9	48·0	47·9	49·1	47·7	48·1	49·5	48·6	50·0	51·7	48·4
1888	43·4	44·1	45·1	46·1	45·8	47·1	45·6	46·1	47·2	46·6	47·8	49·7	46·2
Mean	45·7	46·7	47·2	48·3	48·4	49·3	47·6	48·3	50·4	48·2	49·8	51·1	48·3

Table III. represents the mean temperature for the 12 districts of the British Islands, as well as for the whole area, for the 12 months from October to the following September. It shows that the mean for the year ending September 1888 is exceptionally low, and there is but one other year during the whole period which is equally as cold, the means for the years ending September 1879 and 1888 being both 46°·2. The next lowest is that for 1886, when the mean was 47°·2. The highest mean for the whole of the British Islands is 49°·9 in 1868, and the means for 1874, 1882 and

1884 were all nearly equally as high. In England NE, Midland Counties, England S, England NW, England SW, and Ireland S, the year ending September 1888 was the coldest of any year during the past 22. It is somewhat interesting to learn how closely the means for the several years agree, taking the British Islands as a whole, but yet the maximum difference of 3°·7 is very large when it is considered how long a time this difference is spread over. The largest difference in any district is 5°, which occurs between the years 1868 and 1888 in both the Midland Counties and England SW.

When dealing with the former period, the Greenwich records were examined for a statement of the actual number of days on which the temperature was below the average for 20 years; the results there given are here repeated, so as to complete the period of 14 months, and the following shows the days of excess or defect for the respective months:—

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Total 14 Months.
Days with temp. above the mean.	2	3	12	11	14	7	9	8	13	11	0	7	11	7	115
Ditto below the mean.	28	28	18	20	17	22	22	22	18	19	31	24	19	24	312

This shows that the temperature was below the average for 73 per cent. of the total number of days. The longest periods of continuously low temperature were:—1887, September 7th to October 7th, 31 days; 1888, February 11th to March 5th, 24 days; June 27th to August 6th, 41 days; and September 30th to October 24th, 25 days.

Mr. Mawley has supplied further details showing the departure from average of the past 42 years in the temperature of the soil, at 3 feet below the surface at Greenwich, for the 6 months May to October 1888, so that with the materials previously furnished the means are now complete for the 14 months.

1888.—May.	June.	July.	Aug.	Sept.	Oct.
−0°·8	−0°·7	−3°·0	−2°·1	−1°·4	−2°·9

June was the coldest for 8 years; July the coldest of any during the 42 years, with the exception of 1879; August the coldest for 22 years; and October, the coldest of any during the 42 years, and the coldest on record.

The spell of cold weather here dealt with, long as it may seem, might fairly have embraced also the month of August 1887, when the mean temperature was below the average over nearly the entire kingdom, so that in reality there have been 15 consecutive months with a low mean temperature.

In conclusion, I would acknowledge the assistance derived from the *Weekly Weather Reports* published by the Meteorological Office, since it is from these and their Appendices that most of the facts referred to have been obtained.

DISCUSSION.

The PRESIDENT (Dr. Marcet) said that the subject of this paper was one which was interesting to every one. He was surprised to learn that so many as 73 per cent. of the days embraced in the 59 weeks were below the average. It would be extremely interesting if the cause of this persistent low temperature could be discovered. He thought it possible that the general dampness of the air had had something to do with it, the presence of so much vapour in the atmosphere causing a reduction of temperature.

Mr. TRIPP inquired whether Mr. Harding knew what the air temperature in other parts of the world was during this period. He had found in the course of some rainfall investigations which he was making, that it frequently happened that when one part of the world was excessively wet another part was excessively dry, and he thought it possible that similar extremes of air temperature might prevail, a defect of temperature in one part being counterbalanced by an excess in another.

Mr. MAWLEY said that in considering this paper one could not help recalling the same seasons in 1878-9. Indeed, taking the whole fourteen months, the mean temperature at Greenwich was then only 0°·2 higher than during the same period in 1887-8. At Berkhamsted the cold at the beginning of October was this year remarkably severe, and did great damage to vegetation. The first two frosts of the month, although keen for the season, did not do the slightest injury even to the young shoots and blossoms of the dahlias. But then these were dry frosts. On the night, however, of the 2nd-3rd, when the temperature in the screen fell to 23°·3, and that on the grass to 20°·0, all the dahlias were completely killed, while a large walnut tree growing near them had every leaf destroyed and every walnut on it frozen through. The damage done on this night to the foliage of trees was not confined to the lower parts of the valley, in which the town of Berkhamsted is situated but could be clearly traced all the way up the sides of the hills on either side of it. Among the trees and plants which had their foliage entirely destroyed might be mentioned Acacias (Robinias), Walnuts, Syringas, Keswick Codlin Apples, and Virginia Creepers, and at the bottom of the valley, Limes and Horse-chestnuts; while Sycamores, Nut trees, Hornbeams, and Blenheim Orange-apples suffered severely. The deciduous trees which were least injured were Beeches and Oaks. He considered there were several causes besides the low temperature which conspired to make this frost such a destructive one. (1.) It was a damp frost, the air at 9 p.m. (2nd) being saturated with moisture; besides which the leaves of all plants and trees were at the time wet with the rain and sleet that had fallen during the afternoon. (2.) Again, it was not an ordinary radiation frost, but one in which the entire valley was filled with an almost uniformly cold atmosphere; so that the upper and lower surfaces of the foliage were alike affected. (3.) The length of time the frost lasted, the temperature of the air remaining below the freezing-point for about 12 hours. (4.) Owing to the cold, dull and wet summer the new growths on most trees were not nearly so well ripened as is usual at this season. (5.) The minimum temperature was registered at 7 a.m. on the 3rd, and at 8.30 a.m. the sun was shining brightly and continued to do so for some hours. And, as gardeners know only too well, there is scarcely anything so trying to plants as to be exposed to the direct action of the sun when their foliage is in a frozen condition. Between 8 a.m. and noon the shade temperature rose no less than 29°.

Mr. BALDWIN LATHAM said that the remarkable temperature at the beginning of the present month had caused him to refer back in his registers and make comparisons, and he had found that the temperature registered on the 11th July last was 6° lower than that for the 5th December. It was most curious that while in the southern districts of England the rainfall had been greater than usual, those parts of the country which were usually wet had been comparatively dry. For instance, at Liverpool and throughout Lancashire the rainfall had been much less than usual; indeed Liverpool and the district round nearly ran short of water. As bearing upon this question he mentioned the fact that the number of extensions of time for the completion of contracts on account of inclement weather were four times greater in the southern districts than those in the northern. It was not easy to see how such varying conditions of weather in different places at the same time could be the result of any general law.

Dr. TRIPE said that the low temperature was due to a great extent to the absence of sunshine. It was rather singular that health had been so good, considering the unseasonable character of the weather and the great changes from day to day. He believed it was probable that something like 60,000 fewer deaths had occurred during this year than last. There was little doubt that the cold had been in part caused by the moist atmosphere. Dry burning heat was prejudicial to health, especially to young children and old people, and it was, perhaps, owing to the absence of dry heat that the year had been so healthy.

Mr. HARRIES remarked that it was marvellous that the harvest had turned out so well, seeing that the accumulated temperature was so greatly in defect, the difference of 1646 day-degrees between 1884 and 1888 in no way representing the difference either in the quantity or the quality of the harvests of the two years.

Mr. ELLIS wished to testify to the interest attaching to this paper, as indeed to all papers prepared by Mr. Harding, who, having ready means of dealing with the meteorology of the whole United Kingdom, was able to discuss meteorological questions on a broad basis, instead of considering the records of an isolated station or district only. Referring to the long-continued cold, he remarked that, beginning with December 1886 and ending with October 1888, the monthly mean temperature at Greenwich had been continuously below the average, excepting in the three months of June, July and August 1887, that is in 20 out of 23 consecutive months, being in some months very much below. With November came a change, this month having been warm. The months of July of 1887 and 1888 were in every way in very unusual contrast, the temperature of the former month being much in excess of the average, and that of the latter about as much in defect; the former month had little rain and cloud and an unusual amount of sunshine, whilst the latter was remarkable for much rain and cloud and very little sunshine. These circumstances of course go in a certain sense together, but not often in so extreme a degree. Another instance of strong contrast in temperature is that between the recent months of October and November, the mean temperature of October having been 46°·0, and that of November 47°·0, actually 1°·0 higher, although, on the average, the fall of temperature from October to November is 8°·3.

Mr. C. HARDING, in reply, said he believed that the explanation of the continued cold was to be found in the relative distribution of pressure over North-western Europe. For the last two years there had been a marked absence of great cyclonic disturbances over these islands. The whole distribution of pressure seemed to have been pushed southwards; for while in the British Isles we experienced a very bad summer this year, in Norway it had been exceptionally fine, and yet ships going round the North Cape found the ice to be further southwards than usual. Synchronous charts over a very large area, embracing the whole of the North Atlantic, were required to examine these conditions. The protracted cold experienced in the British Isles was due to cyclonic conditions prevailing in the summer and anticyclonic in the winter, a reversal of the normal conditions.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1888.

By the Rev. T. A. PRESTON, M.A., F.R.Met.Soc.

[Received November 22nd.—Read December 21st, 1888.]

I have endeavoured in this Report to comply with the suggestions which have been made with regard to my previous Reports, but have been met by a difficulty which I had not appreciated before, and which, in fact, could not be estimated until after some years' experience, and that is, the irregularity of observers, and what I have hitherto called the "personal equation." Though we have had no less than 128 observers, more than half of them gave up after 1, 2, or 3 years' work; a very large proportion of the remainder declined to send specimens, and their returns were often too doubtful to be of any value; and of those whose observations were available, many were in the South of England and none really in the Northern counties.

Again, after selecting the Stations, I found that, however I might vary the plants to be selected, I could not go further back than 6 out of the 14 years (including the present year) during which the observations have been continued; and moreover that I could only go as far as July in each year, the records for the other months being too incomplete.

Without, therefore, entering into details about each particular plant or station, I may say that I have been reluctantly compelled to omit some, which would otherwise have been very desirable, and to admit others which I would have been equally glad to discard.

I have given in Table I. the returns from those Stations where a fair number of observations have been taken during the year. The records from all the Stations have been entered in a MS. book for easy reference.

In order to reduce the number of Stations, I have selected one or two in each of the districts of the Meteorological Office where available, as follows:—

(0).	None.	(6).	Tynron.
(1).		(7).	Macclesfield.
(2).		(8).	Babbacombe and Wells.
(3).	Tacolneston.	(9).	None.
(4).	Oxford and Hodsock.	(10).	Wicklow.
(5).	Salisbury and Marlborough.	(11).	Guernsey.

I could have wished to retain Northampton, Croydon, and Westward Ho, but they would have made three Stations in a district.

The reduction of the number of the species to be observed has been a very difficult matter; of course all those species about which errors had been frequent were at once cut out. Taking those particular species which had

TABLE I.—Date (Day of Year) of First Flowering of Plants, 1888.

Name of Plant.	Babbacombe.	Buckhorn Weston.	Westward Ho.	Salisbury.	Marlborough.	Strathfield Turgiss.	Pennington.	Croydon.	Ealing.	Oxford.	Northampton.	Harpenden.	Hertford.	Hodsock.	Settle.	Killarney.	Wicklow.	Guernsey.	Norwich.
Anemone nemorosa.....	..	115	..	95	101	113	109	106	..	106	112	105	92	105	104	65	100	103	110
Ranunculus ficaria	66	72	47	61	69	105	92	77	90	97	90	97	57	68	85	38	38	33	67
Ranunculus aeris	141	134	140	132	121	142	136	141	127	136	131	131	127	143	146	131	..	124	127
Caltha palustris	103	116	..	96	101	113	97	115	..	120	93	118	106	111	109	75	114	117	116
Nasturtium officinale	..	161	151	145	165	179	152	173	..	164	161	..	131	168	149	167	..	137	127
Cardamine pratensis.....	120	116	..	117	117	123	119	126	129	122	130	129	113	127	130	110	..	125	128
Sisymbrium Alliaria	..	116	118	120	128	132	125	127	129	117	135	132	120	124	149	112	117	115	125
Lychnis Flos-cuculi	158	153	161	151	155	153	156	161	..	155	159	162	159	162	179	166	..	146	159
Stellaria Holostea	107	126	126	115	124	125	98	126	127	129	133	117	110	132	132	104	105	..	119
Malva sylvestris	168	173	162	168	175	180	170	175	176	173	176	179	160	171	198	170	161	163	160
Geranium Robertianum..	126	135	129	133	142	137	139	142	..	136	141	141	142	141	139	129	140	119	143
Acer Pseudo-platanus	..	136	141	126	135	145	134	134	127	134	131	147	134	122	124	..	117	136	133
Æsculus Hippocastanum ..	..	143	143	138	140	140	141	140	141	138	143	142	141	136	146	127	..	..	142
Cytisus Laburnum	142	148	144	145	145	155	144	141	141	142	146	148	..	145	152	133	..	135	147
Trifolium repens	160	157	149	150	157	171	156	155	160	164	161	163	153	159	163	149	155	130	..
Lotus corniculatus	142	141	138	139	140	172	143	147	150	151	152	154	148	155	144	136	126	137	..
Vicia Cracca.....	182	163	168	163	175	178	179	165	175	176	192	170	173	177	191	169	173	177	194
„ *sepium*.....	132	133	140	133	134	144	136	138	155	146	152	143	134	143	146	108	113	151	..
Lathyrus pratensis	158	153	149	159	161	164	170	161	164	171	187	166	169	176	179	..	156	184	170
Prunus spinosa	102	122	..	112	124	127	115	120	..	124	126	119	110	119	126	89	37	97	120
Spiræa Ulmaria	188	171	176	183	180	176	185	185	196	178	187	..	180	..	191	181	177	..	..
Potentilla anserina	148	147	141	150	147	154	143	161	157	145	155	160	142	162	163	143	145	138	169
Rosa canina	168	167	164	166	159	157	163	163	168	171	166	164	165	167	177	158	168	179	173
Cratægus Oxyacantha	145	146	141	145	147	151	144	141	145	145	148	148	142	144	158	133	128	139	145
Epilobium hirsutum.....	203	201	187	216	196	206	206	..	201	..	..	200	203	204	229	..	..	196	207
„ *montanum*	..	..	159	171	161	183	170	175	169	..	174	170	176	171	171	161	171	165	..
Syringa vulgaris	140	141	135	133	162	155	141	140	138	138	141	139	..	139	149	129	130	129	143

TABLE I.—Date (Day of Year) of First Flowering of Plants, 1888.—*Continued.*

Name of Plant.	Babbacombe.	Buckhorn Weston.	Westward Ho.	Salisbury.	Marlborough.	Strathfield Turgiss.	Pennington.	Croydon.	Ealing.	Oxford.	Northampton.	Harpenden.	Hertford.	Hodsock.	Settle.	Killarney.	Wicklow.	Guernsey.	Norwich.
Galium Aparine	149	147	137	137	140	156	143	142	148	142	145	143	138	147	170	148	161	151	147
,, *verum*	182	178	181	181	181	199	191	183	..	183	187	189	183	198	186	177	179	171	..
Tussilago Farfara	74	67	67	68	81	95	88	70	97	92	90	96	60	81	63	62	82	67	121
Achillea Millefolium ..	180	172	164	156	163	162	171	175	178	188	159	175	162	178	173	178	171	158	165
Chrysanthemum Leucanth.	143	145	152	147	154	149	156	152	151	151	149	152	151	157	170	148	145	137	143
Senecio Jacobæa	196	153	183	170	180	185	194	190	..	..	..	..	190	201	191	181	192	160	..
Centaurea nigra.....	194	195	189	174	175	179	171	175	178	176	193	184	176	183	193	190	195	187	..
Carduus arvensis].....	188	185	183	194	188	176	185	182	183	..	..	189	183	194	209	177	..	189	..
Hieracium Pilosella	150	143	153	142	154	152	148	158	157	..	159	159	144	147	163	143	145	138	..
Campanula rotundifolia	..	210	..	192	178	199	178	..	..	..	203	176	190	190	191	..	..	..	200
Ligustrum vulgare	182	178	..	177	189	191	185	183	183	177	187	180	183	182	216	160	167	172	..
Convolvulus sepium	229	192	..	211	200	191	209	..	209	..	204	217	199	187	238	192	197	181	..
Symphytum officinale	186	144	152	140	138	166	136	153	141	136	..	..	144	..	170	162	149	160	..
Veronica Chamædrys	107	126	124	119	133	137	130	134	141	136	141	140	127	133	144	134	117	107	126
Prunella vulgaris.....	165	170	168	170	163	186	171	183	176	171	166	182	169	184	187	161	171	..	194
Nepeta Glechoma	96	96	..	100	120	101	127	114	141	122	..	124	113	121	130	81	99	107	121
Stachys sylvatica	..	174	180	176	168	173	171	175	169	178	175	166	169	178	187	170	172	178	..
Ajuga reptans	149	133	135	140	143	143	136	140	137	146	152	148	141	140	149	..	132	136	141
Primula veris.....	102	104	..	112	118	105	125	120	120	113	119	96	93	117	119	100	113	..	122
Plantago lanceolata	120	127	129	128	123	129	130	133	135	130	131	139	127	129	132	129	102	115	159
Mercurialis perennis.....	76	83	115	70	74	107	98	71	..	97	107	79	90	87	94	..	..	..	106
Corylus Avellana.....	23	65	32	28	40	39	26	29	..	..	42	27	43	10	23	12	17	24	67
Orchis maculata	172	154	..	157	159	172	159	168	..	..	161	169	153	..	166	165	166	156	..
Iris Pseud-acorus.....	165	..	155	161	165	163	169	175	..	164	175	182	162	173	176	148	..	144	161
Galanthus nivalis.....	..	25	..	9	29	43	..	39	58	..	69	33	40	26	26	10	13	14	27
Scilla nutans	118	124	..	126	124	130	131	133	134	132	133	129	127	130	131	106	117	110	134

TABLE II.

DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS IN EACH YEAR, 1883 TO 1888.

District.	Station.	Corylus Avellana.							Ranunculus Ficaria.						
		1883.	1884.	1885.	1886.	1887.	Average.	1888.	1883.	1884.	1885.	1886.	1887.	Average.	1888.
3	Tacolneston	..	..	..	..	36	..	24	..	26	67	81	58	58	79
4	Oxford.....	..	14	41	71	33	40	90	36	20	46	67	..	42	97
4	Hodsock	..	10	29	26	29	23	10	60	14	54	79	70	55	68
5	Salisbury ..	15	10	30	32	22	22	28	6	14	38	79	43	36	61
5	Marlborough	18	16	34	27	36	26	40	3	11	36	14	35	20	69
6	Tynron	..	..	..	..	58	..	92	..	..	..	..	99	..	109
7	Macclesfield	..	40	42	..	..	..	69	34	60	91	..	95	70	95
8	Babbacombe	49	59	32	61	38	48	23	53	33	55	57	72	54	66
8	Wells	23	22	34	46	35	32	37	10	15	60	56	51	38	79
10	Wicklow	..	19	29	51	24	31	17	26	19	53	53	44	39	38
Chan. Islnds.	Guernsey ..	..	..	33	..	..	..	24	..	..	25	20	..	..	33

District.	Station.	Tussilago Farfara.							Caltha Palustris.						
		1883.	1884.	1885.	1886.	1887.	Average.	1888.	1883.	1884.	1885.	1886.	1887.	Average.	1888.
3	Tacolneston	..	..	..	..	..	..	97	102	53	94	96	113	92	110
4	Oxford.....	42	47	49	84	90	62	92	57	70	83	94	106	82	120
4	Hodsock	..	56	73	81	54	66	81	107	90	107	108	109	104	111
5	Salisbury ..	51	66	..	79	82	69	68	59	67	91	93	94	81	96
5	Marlborough	34	51	55	80	36	51	81	14	76	90	83	81	69	101
6	Tynron	..	..	..	..	86	..	103	..	..	..	..	124	..	131
7	Macclesfield	..	60	73	..	..	..	95	115	83	106	..	134	109	108
8	Babbacombe	85	70	72	84	87	80	74	53	71	72	95	88	76	103
8	Wells	37	62	69	95	..	66	..	63	77	77	..	105	81	109
10	Wicklow ..	..	64	..	79	67	70	82	85	94	100	96	120	99	114
Chan. Islnds.	Guernsey ..	..	54	..	..	..	..	67	..	..	..	104	115	..	117

District.	Station.	Nepeta Glechoma.							Cardamine Pratensis.						
		1883.	1884.	1885.	1886.	1887.	Average.	1888.	1883.	1884.	1885.	1886.	1887.	Average.	1888.
3	Tacolneston	..	..	92	101	78	90	115	108	94	113	112	..	107	124
4	Oxford.....	88	80	77	106	99	90	122	110	84	109	115	112	106	122
4	Hodsock	..	93	109	119	108	107	121	118	95	116	123	115	113	127
5	Salisbury ..	62	70	86	93	89	80	100	93	86	100	105	105	98	117
5	Marlborough	75	76	90	90	85	83	120	90	81	102	117	111	100	117
6	Tynron	..	..	..	..	132	..	135	..	..	..	..	..	..	..
7	Macclesfield	..	112	115	..	134	120	..	111	113	..	..	..	..	..
8	Babbacombe	83	74	87	100	74	84	96	136	113	111	114	125	120	120
8	Wells..	64	67	85	103	98	83	..	110	88	112	118	124	110	119
10	Wicklow	..	81	99	113	107	100	99	112	100	117	125	127	116	..
Chan. Islnds.	Guernsey ..	..	80	..	115	105	100	107	..	92	..	117	120	110	125

TABLE II.

DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS IN EACH YEAR, 1883 TO 1888—*Continued.*

District.	Station.	VERONICA CHAMÆDRYS.							GERANIUM ROBERTIANUM.						
		1883.	1884.	1885.	1886.	1887.	Average.	1888.	1883.	1884.	1885.	1886.	1887.	Average.	1888.
3	Tacolneston	..	100	122	119	122	116	124	..	136	125	117	133	128	136
4	Oxford ...	110	108	117	124	128	117	136	122	103	103	118	129	115	136
	Hodsock ..	..	121	135	137	137	132	133	135	134	139	141	149	140	141
5	Salisbury ..	90	68	113	107	108	97	119	127	99	124	125	137	122	133
	Marlborough	103	90	110	124	120	109	133	139	143	141	129	146	140	142
6	Tynron	..	..	..	..	135	..	..	..	..	..	..	154	..	160
7	Macclesfield	..	133	136	..	150	140	143	148	152	164	..	..	155	158
8	Babbacombe	117	100	119	104	96	107	107	117	67	92	105	109	106	126
	Wells	61	97	115	..	131	101	139	59	31	113	121	131	122	137
10	Wicklow ..	..	74	122	127	129	113	117	120	110	134	126	114	121	140
Chan. Islnds.	Guernsey ..	..	52	111	83	109	89	107	..	46	111	123	111	115	119

District.	Station.	CRATÆGUS OXYACANTHA.							ROSA CANINA.						
		1883.	1884.	1885.	1886.	1887.	Average.	1888.	1883.	1884.	1885.	1886.	1887.	Average.	1888.
3	Tacolneston	..	130	133	143	148	138	144	154	157	158	166	171	161	165
4	Oxford	135	123	146	132	142	136	145	163	162	159	163	166	163	171
	Hodsock ..	137	128	142	142	154	141	144	165	159	164	173	170	166	167
5	Salisbury ..	136	133	136	..	143	137	145	154	156	163	160	166	160	166
	Marlborough	142	138	148	142	148	144	147	156	160	164	161	167	162	159
6	Tynron	..	..	..	..	156	..	160	..	..	..	..	166	..	172
7	Macclesfield	146	141	..	..	160	149	156	167	166	..	..	179	174	..
8	Babbacombe	140	123	129	139	141	134	145	161	154	165	163	167	162	168
	Wells	135	122	133	133	148	134	147	153	154	161	159	152	156	162
10	Wicklow ..	..	..	129	147	138	138	128	..	162	168	171	164	166	168
Chan. Islnds.	Guernsey ..	..	111	121	127	140	125	139	..	..	164	155	..	160	179

District.	Station.	VICIA CRACCA.							GALIUM VERUM.						
		1883.	1884.	1885.	1886.	1887.	Average.	1888.	1883.	1884.	1885.	1886.	1887.	Average.	1888.
3	Tacolneston	170	169	179	171	177	173	..	..	..	181	..	..	..	..
4	Oxford	..	..	171	179	176	175	176	..	181	182	195	181	185	183
	Hodsock ..	..	..	183	185	186	185	177	..	181	193	192	186	188	198
5	Salisbury ..	161	170	163	167	174	167	163	181	176	177	183	174	178	181
	Marlborough	172	176	170	175	174	173	175	179	179	185	184	179	181	181
6	Tynron	..	..	..	..	158	..	..	..	..	..	..	166	..	..
7	Macclesfield	167	173	..	..	177	172	..	..	187	..	..	..	..	..
8	Babbacombe	179	174	176	175	179	177	182	181	182	184	178	177	180	182
	Wells	173	186	179	174	..	178	183	186	187	189	186	180	186	183
10	Wicklow ..	..	188	177	178	172	179	173	..	..	160	194	192	182	179
Chan. Islnds.	Guernsey ..	..	182	166	169	180	174	177	..	158	191	158	166	155	171

TABLE III.

AVERAGE DATE (DAY OF YEAR) OF FIRST FLOWERING IN EACH DISTRICT, TOGETHER WITH THE AVERAGE ACCUMULATED TEMPERATURE ABOVE AND BELOW 42°, RAINFALL, AND SUNSHINE FOR THE SIX YEARS, 1883–88.

Date.	District 3.					District 4.					District 5.					District 6.				
	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.
Jan.		°	°	In.	Hr.		°	°	In.	Hr.		°	°	In.	Hr.		°	°	In.	Hr.
1883	..	26	112	1·94	50	..	42	99	2·89	46	16	57	64	2·38	46	..	33	74	5·67	33
1884	..	74	56	1·39	31	12	81	45	2·25	25	13	90	27	2·24	30	..	67	43	6·70	21
1885	..	0	218	1·60	33	35	1	220	1·22	14	32	6	178	1·23	19	..	5	146	2·54	23
1886	..	12	226	2·71	54	48	18	214	3·00	46	30	30	173	3·32	50	..	23	169	4·98	35
1887	36	17	215	1·39	43	31	37	205	1·91	41	29	33	160	1·73	36	58	49	129	4·21	33
Average	..	26	165	1·81	42	32	36	157	2·25	34	24	43	120	2·18	36	..	35	112	4·82	29
1888	24	26	137	0·64	55	50	29	149	0·52	43	34	26	131	0·77	45	92	32	85	3·87	31
Feb.																				
1883	..[1]	70	100	2·75	96	45	74	97	3·27	84	23	92	58	3·98	82	..	58	59	4·26	63
1884	26	83	65	1·25	58	36	80	73	2·38	49	36	98	25	2·64	53	..	54	61	6·48	42
1885	67	78	74	2·18	49	50	77	78	3·41	46	43	99	45	3·86	45	..	37	90	5·91	42
1886	81	0	225	0·74	59	79	1	192	1·43	42	63	8	168	1·32	45	..	7	144	3·25	29
1887	58	43	162	0·67	117	71	62	151	0·54	100	49	60	122	0·71	86	92	41	83	3·56	72
Average	58	55	125	1·52	76	56	59	118	2·21	64	43	71	84	2·50	62	..	39	87	4·69	50
1888	79	8	220	1·56	45	84	14	214	1·29	52	70	16	209	1·63	46	106	20	163	1·34	79
March.																				
1883	..	43	247	1·73	166	..	62	250	1·19	161	52	59	198	1·15	179	..	42	168	2·24	153
1884	..	123	116	1·23	117	83	130	115	2·06	105	72	142	67	1·85	113	..	82	83	3·93	79
1885	93	93	157	1·50	138	94	92	144	1·47	116	89	97	122	2·25	123	..	68	123	3·43	123
1886	99	84	233	1·44	85	107	89	244	2·03	85	90	69	214	1·69	85	..	41	196	2·95	86
1887	95	79	197	1·69	150	105	77	191	1·63	106	88	86	171	1·70	139	128	72	135	1·97	126
Average	98	84	190	1·52	131	97	90	189	1·68	115	78	91	154	1·73	128	..	61	141	2·90	113
1888	113	37	211	2·89	77	117	38	207	2·74	81	105	41	177	3·43	71	133	23	190	3·42	132
April.																				
1883	108	171	46	1·73	148	112	196	45	1·51	134	94	181	31	1·30	153	..	136	35	2·22	130
1884	97	126	72	1·42	125	102	132	78	1·43	99	81	142	64	1·56	101	..	137	35	0·82	123
1885	117	162	71	1·46	160	120	152	73	2·03	134	106	189	42	1·36	158	..	121	54	2·80	142
1886	116	145	42	1·49	129	125	151	46	2·23	117	113	160	25	1·70	133	..	102	51	3·16	141
1887	122	128	90	1·15	175	123	129	117	1·19	163	111	138	71	1·52	170	..	109	92	2·52	179
Average	112	146	64	1·45	147	116	152	72	1·68	129	101	162	47	1·49	143	..	121	53	2·30	143
1888	124	114	73	1·53	111	130	116	67	1·49	84	121	108	55	1·54	100	..	99	56	2·72	116
May.																				
1883	..	264	13	1·65	188	132	260	19	1·64	141	136	284	8	2·12	179	..	192	20	2·41	180
1884	133	300	12	1·06	216	122	285	10	0·99	194	128	312	3	0·84	185	..	198	9	3·60	146
1885	129	174	39	3·14	168	133	178	43	2·16	158	137	192	15	2·85	170	..	135	40	2·42	146
1886	130	247	24	2·57	154	133	252	24	4·77	123	135	283	10	3·05	164	..	167	18	3·32	127
1887	140	190	11	1·89	116	144	199	6	1·28	114	143	231	0	1·22	139	155	231	6	1·76	165
Average	133	235	20	2·06	168	133	235	20	2·17	146	136	260	7	2·02	167	..	185	19	2·70	153
1888	140	261	20	0·69	197	141	264	17	0·76	197	142	258	5	1·20	199	160	222	11	2·88	193
June.																				
1883	162	519	0	3·36	264	(164)	507	0	4·03	227	161	557	0	1·63	243	..	419	0	3·16	211
1884	163	453	0	1·30	234	(160)	477	1	1·79	183	165	514	0	2·32	197	..	431	0	0·94	203
1885	168	516	0	1·90	249	169	507	0	2·65	242	165	550	0	1·80	256	..	388	0	2·07	207
1886	169	431	0	1·17	232	175	423	0	2·36	185	166	484	0	1·65	251	..	336	1	2·29	182
1887	174	598	0	0·55	320	175	632	0	1·54	300	170	614	0	1·09	318	..	544	0	1·50	272
Average	167	503	0	1·66	260	169	509	0	2·47	227	165	544	0	1·70	253	..	424	0	1·99	215
1888	(165)	476	0	2·83	179	173	449	0	3·76	162	166	492	0	3·41	174	..	397	0	5·76	232

[1] Dates for RANUNCULUS FICARIA only.

TABLE III.

AVERAGE DATE (DAY OF YEAR) OF FIRST FLOWERING IN EACH DISTRICT, TOGETHER WITH THE AVERAGE ACCUMULATED TEMPERATURE ABOVE AND BELOW 42°, RAINFALL, AND SUNSHINE FOR THE SIX YEARS, 1883–88—*Continued.*

Date.	District 7.					District 8.					District 10.					Channel Islands.				
	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.	Flowering.	Accumulative Temp. Above 42°.	Accumulative Temp. Below 42°.	Rainfall.	Sunshine.
Jan.		°	°	In.	Hr.		°	°	In.	Hr.		°	°	In.	Hr.		°	°	In.	Hr.
1883	..	35	83	4·68	41	36	94	26	3·28	49	..	96	36	5·43	52	..	118	12	2·55	62
1884	40	69	34	4·19	13	40	106	9	3·39	18	19	130	13	4·13	23	..	131	0	2·77	50
1885	42	4	161	1·27	10	33	23	129	2·26	28	29	62	91	3·16	48	33	38	74	2·26	36
1886	..	19	167	4·20	33	54	34	147	4·33	49	51	39	138	2·84	39	..	61	55	3·12	59
1887	..	35	149	2·49	36	36	52	90	2·85	42	24	84	81	3·92	53	..	62	47	2·35	92
Average	..	32	119	3·57	27	40	62	80	3·22	37	31	82	72	3·90	43	..	82	38	2·61	60
1888	69	24	96	1·31	33	30	39	98	1·60	46	17	76	46	2·84	56	24	70	38	1·46	75
Feb.																				
1883	..	64	63	2·31	71	46	92	48	5·53	78	..	97	66	6·40	69	..	81	8	4·15	118
1884	60	67	62	4·42	36	45	98	21	4·56	41	42	103	35	5·81	55	..	123	1	3·10	71
1885	82	53	73	3·89	29	64	103	42	4·50	44	..	93	62	5·53	71	..	125	6	4·02	67
1886	..	5	155	2·25	38	73	13	143	2·43	52	66	42	96	3·63	60	..	39	49	2·03	74
1887	..	47	117	1·18	90	74	64	101	0·82	104	55	101	84	1·78	98	..	66	52	0·75	109
Average	..	47	94	2·81	53	60	74	71	3·57	64	54	87	65	4·63	71	..	87	23	2·81	88
1888	95	6	162	1·01	67	73	19	181	1·14	80	60	29	124	1·03	68	50	32	103	1·98	39
March.																				
1883	..	51	195	1·47	158	66	75	153	1·62	197	..	89	124	1·96	161	..	66	96	2·14	195
1884	98	94	89	2·88	85	72	128	39	4·25	114	87	144	45	5·44	89	..	161	4	3·31	184
1885	110	66	114	2·53	110	80	100	93	2·33	139	100	128	101	3·06	138	..	114	19	1·90	165
1886	..	65	235	2·55	100	99	74	172	3·99	85	104	81	128	4·71	104	109	85	94	3·75	129
1887	134	54	149	2·22	131	92	90	151	1·86	187	114	114	111	1·87	158	110	87	64	1·15	206
Average	114	66	156	2·33	116	82	93	122	2·81	144	101	111	102	3·41	130	..	103	55	2·45	176
1888	..	28	188	2·69	117	101	48	162	4·32	128	107	66	149	3·76	136	112	66	84	3·86	125
April.																				
1883	..	150	32	1·54	138	106	156	21	1·10	188	112	172	33	2·46	184	..	154	1	1·50	210
1884	..	120	63	0·99	123	100	130	36	1·98	145	87	165	29	1·65	155	72	146	4	1·73	157
1885	..	122	55	2·15	126	114	140	48	2·51	162	120	144	52	3·56	130	111	155	7	1·87	198
1886	..	117	37	2·78	117	112	145	23	2·67	139	126	152	33	2·78	133	100	145	4	2·20	165
1887	..	101	82	1·20	174	119	141	64	1·71	212	128	144	79	1·52	231	114	131	7	1·83	200
Average	..	122	54	1·73	136	110	142	38	1·99	169	115	155	45	2·39	167	99	146	5	1·83	186
1888	..	89	49	1·59	94	121	104	44	1·62	119	..	130	33	2·05	108	116	119	22	1·87	142
May.																				
1883	147	219	15	1·15	196	127	243	10	2·18	159	120	232	5	2·46	193	..	263	0	1·96	217
1884	146	244	6	1·93	176	122	251	0	1·40	181	110	257	5	2·00	149	111	303	0	0·83	231
1885	164	141	22	1·74	154	117	159	19	3·33	179	132	163	22	2·46	177	116	189	0	2·73	245
1886	..	206	18	3·61	121	125	258	5	2·92	157	131	225	2	3·69	119	125	288	0	2·23	177
1887	160	191	4	1·74	139	132	235	0	1·17	165	126	268	0	1·04	168	125	243	0	1·29	190
Average	154	200	13	2·03	157	125	229	7	2·20	168	124	229	7	2·33	161	119	257	0	1·81	212
1888	157	236	4	0·79	184	139	245	2	1·37	219	134	263	0	2·21	211	129	268	0	1·07	263
June.																				
1883	167	476	0	3·25	216	166	486	0	2·83	234	..	466	0	2·67	199	..	518	0	2·39	296
1884	170	446	0	0·91	215	167	497	0	1·52	255	175	474	0	0·99	184	(182)	493	0	2·38	311
1885	..	432	0	2·13	212	170	477	0	2·88	222	173	437	0	1·79	230	165	474	0	1·37	239
1886	..	377	0	3·02	187	168	440	0	1·74	255	174	443	4	1·69	197	162	466	0	1·79	284
1887	178	593	0	0·85	315	170	633	0	0·58	361	168	664	0	0·76	310	(180)	629	0	0·63	353
Average	172	465	0	2·03	229	168	507	0	1·91	265	172	497	1	1·58	224	172	516	0	1·71	297
1888	..	423	0	3·97	187	174	468	0	4·47	189	170	491	0	5·80	191	178	502	0	3·67	221

TABLE IV.—DATE (DAY OF YEAR) OF FIRST SONG, MIGRATION AND NESTING OF BIRDS, 1888.

Stations.	Song.									Migration.		
	Brown Owl.	Song Thrush.	Nightingale.	Willow Wren.	Chiff-chaff.	Skylark.	Chaffinch.	Cuckoo.	Turtle Dove.	Flycatcher.	Wheatear.	Swallow.
Durham	..	..	..	128	..	37	62	122	..	130	128	112
Cotherstone	..	..	..	..	..	..	..	122	..	..	..	123
Tacolneston	..	10	119	109	..	8	..	119	133	..	..	117
Norwich	..	..	120	..	..	..	..	110	..	..	..	..
Ware	..	..	..	..	..	38	..	111	..	..	..	108
Harpenden	74	8	116	..	..	8	..	112	..	..	..	106
Hodsock	..	38	118	121	..	24	121	124	127	159	..	107
Northampton	..	..	..	..	106	..	..	107	..	..	101	106
Addington	..	..	123	..	..	..	101	112	..	..	..	106
Oxford	..	..	..	..	..	..	66	117	..	..	..	107
Detling	..	..	111	..	..	..	..	107	..	..	..	110
Cranleigh	..	..	115	..	..	..	..	115	..	..	..	..
Ealing	..	..	..	..	..	..	..	114	..	..	..	104
Sittingbourne	..	..	115	..	..	..	..	115	..	..	..	115
Croydon	..	7	119	..	..	41	..	119	..	..	..	113
Henley	..	..	119	..	..	..	..	..	..	..	..	106
Wellington College	..	..	112	..	..	10	26	..	..	..	..	100
Strathfield Turgiss	..	70	111	115	107	65	95	112	127	146	97	105
Marlborough	..	39	129	108	..	43	76	117	129	150	104	107
Salisbury	..	..	..	..	..	..	..	112	..	..	..	105
Buckhorn Weston	..	23	118	119	..	70	112	108	..	149	..	110
Pennington	..	..	109	..	..	..	37	110	..	..	..	106
Tynron	..	..	..	..	..	..	..	..	..	..	..	122
Macclesfield	..	38	..	..	..	67	..	125	..	..	..	..
Westward Ho	..	37	..	..	..	66	..	113	..	..	75	106
Tiverton	..	..	..	..	..	..	..	119	..	..	..	114
Babbacombe	..	..	..	..	..	..	..	125	107	..	..	129
Cushendun	..	..	..	110	110	..	59	105	..	..	..	106
Wicklow	..	..	..	106	113	82	..	122	..	..	..	109
Killarney	..	8	..	104	..	62	76	126	..	..	..	108
Guernsey	..	..	..	..	..	19	..	107	..	..	..	103
Average 1888	74	28	117	113	109	43	76	115	125	127	101	110
,, 1887	..	27	116	112	102	38	64	113	125	140	107	109
,, 1886	..	40	114	110	105	53	55	111	111	140	86	105
,, 1885	..	30	112	100	90	44	51	113	127	133	106	106
,, 10 years	..	22	113	106	92	36	43	113	133	138	100	108

been selected for careful observation, I found that the records of most of them were too imperfect; and it was only after much detailed work that I selected those given below. Here, again, I have had to cut out many which I should have preferred to retain.

The plants selected are :—

For January. *Corylus Avellana* (Hazel).

,, February. *Ranunculus Ficaria* (Pilewort), and *Tussilago Farfara* (Coltsfoot).

,, March. *Caltha palustris* (Marsh Marigold), and *Nepeta Glechoma* (Ground Ivy).

,, April. *Cardamine pratensis* (Cuckoo-flower), and *Veronica Chamædrys* (Germander Speedwell).

TABLE IV.—DATE (DAY OF YEAR) OF FIRST SONG, MIGRATION AND NESTING OF BIRDS, 1888—*Continued.*

Stations.	Migration.					Nesting.						
	House Martin.	Sand Martin.	Swift.	Goatsucker.	Corncrake.	Song Thrush.		Rook.			Partridge.	
						Eggs.	Young.	Building.	Eggs.	Young.	Eggs.	Young.
Durham	138	125	132	..	118	116	..	84	..	..	..	..
Cotherstone	..	..	..	..	141	..	..	..	..	..	..	..
Tacolneston	135	116	..	..	..	..	..	72	..	..	..	..
Norwich.....	..	..	..	..	..	..	..	..	..	..	..	..
Ware	129	..	131	..	133	..	..	..	..	..	..	..
Harpenden	112	..	133	..	135	..	..	66	..	..	..	..
Hodsock	121	120	130	162	121	89	94	67	90	111	119	169
Northampton ..	120	117	128	..	127	..	..	81	..	..	..	..
Addington.....	..	119	129	..	137	84	..	65	..	..	128	178
Oxford	..	..	129	..	133	..	..	..	..	..	..	..
Detling	..	..	..	..	..	..	..	..	..	..	..	..
Cranleigh	..	..	..	..	131	..	..	..	..	..	..	..
Ealing	..	..	136	..	..	..	..	..	..	..	..	..
Sittingbourne ..	..	..	..	..	..	..	..	..	..	..	..	..
Croydon.....	..	..	..	..	..	..	..	..	..	..	..	..
Henley	..	..	..	..	..	..	..	68	..	..	..	..
Wellington Col...	..	..	131	179	..	..	..	..	..	..	..	..
Strathfield T. ..	130	94	135	143	136	76	..	94	108	126	109	..
Marlborough....	115	115	120	..	..	100	..	..	89	..	..	..
Salisbury	115	115	137	..	124	..	..	64	..	87	..	..
Buckhorn W. ..	109	..	121	154	130	..	112	83	..	96	..	..
Pennington	..	..	126	152	135	94	..	..	125	..	..	..
Tynron	123	132	..	..	132	..	..	..	..	..	..	..
Macclesfield	123	..	136	..	132	..	..	86	95	..	..	..
Westward Ho. ..	108	..	122	..	129	78	..	..	..	..	..	..
Tiverton	..	..	..	..	..	..	..	..	..	..	..	..
Babbacombe	..	..	134	..	148	..	..	..	..	..	..	..
Cushendun	127	..	143	..	118	..	..	69	..	..	..	..
Wicklow	107	..	132	..	..	..	..	..	..	..	..	..
Killarney	..	..	144	..	121	..	..	59	..	..	..	..
Guernsey	115	..	..	..	123	..	..	..	..	..	..	..
Average 1888 ..	120	117	131	158	130	91	103	74	101	105	119	173
,, 1887 ..	115	114	132	140	126	94	..	65	87	..	..	..
,, 1886 ..	114	107	129	149	129	93	..	67	..	..	..	..
,, 1885 ..	112	113	124	136	125	85	..	53	..	..	..	..
,, 10 years	(116)	(113)	131	..	(127)	(88)	..	(59)	..	..	..	..

For May. *Geranium Robertianum* (Herb Robert), and *Crataegus Oxyacantha* (Hawthorn).

,, June. *Rosa Canina* (Dog Rose), and *Vicia Cracca* (Tufted Vetch).

,, July. *Galium verum* (Yellow Bedstraw).

In Table III. I have given the average date of flowering in each district, the average accumulated temperature above and below 42°, the average rainfall, and the average duration of sunshine for the six years 1883-88, and also the means for the five years 1883-87.

Backward as the seasons of 1886 and 1887 were, that of 1888 was very much more so. The only month in which the amount of accumulated temperature above 42° was above the mean was May, and even then not in the

TABLE V.—DATE (DAY OF YEAR) OF FIRST APPEARANCE OF INSECTS AND FROG SPAWN, 1888.

Station.	*Melolontha vulgaris.*	*Rhizotrogus solstitialis.*	*Timarcha levigata.*	*Lampyris noctiluca.*	*Apis mellifica.*	*Vespa vulgaris.*	*Pieris Brassicæ.*	*Pieris Rapæ.*	*Anthocharis Cardamines.*	*Epinephile Janira.*	*Bibio Marci.*	*Gonepteryx Rhamni.*	Frog Spawn.	Tadpoles.
Durham	..	..	..	..	98	127	174	125	155	..	..	..	98[1]	..
Cotherstone	..	..	..	..	156	..	163	143	..	..	..	..	106	..
Tacolneston	..	..	..	..	66	133	..	..	139	..	..	105	..	..
Ware	..	..	..	..	..	..	..	129	..	..	..	..	92	..
Harpenden ..	..	..	108	190	75	129	104	121	153	107	..	..	90	..
Hodsock	..	..	..	..	150	..	122	130	..	..	..	..	80	120
Northampton	..	..	..	..	..	..	..	..	140	..	..	..	90	..
Addington ..	..	..	..	..	152	129	139	132	132	182	..	104	93	..
Oxford	..	..	..	..	75	121	130	121	145	..	..	136	..	..
Detling	..	..	..	..	73	..	..	105	(149)	..	..	104	..	..
Ealing	..	..	..	..	75	..	139	119	..	183	134	..	88	..
Croydon	..	..	..	..	..	..	134	106	..	..	..	..	93?	..
Henley.....	..	..	106	..	18	66	..	..	..	..	..	..	71	..
Strathfield T.	155	..	138	176	104	129	154	106	139	147	128	..	67	97
Marlborough	146	..	..	..	..	123	..	..	..	..	..	..	..	..
Salisbury ..	..	..	..	..	70	136	129?	122?	145	..	..	..	65	107
Buckhorn W.	108	..	144	116	7	111	115	..	130	191	..	..	93	133
Pennington	131	.	..	197	145	124	121	140	135	185	..	72	40	134
Macclesfield	..	..	..	..	..	126	148	128	..	..	..	..	..	..
Westward Ho	147	..	137	101	..	140	140	139	134	170	..	..	..	..
Babbacombe	..	..	..	..	103	..	..	126	..	..	..	..	..	..
Cushendun ..	..	..	..	..	143	..	..	..	130	..	142	..	31	..
Wicklow	..	..	..	..	89	..	140	117	117	147	..	..	77	..
Killarney ..	133?	..	..	..	65	104	..	97	140	..	..	..	21	..
Guernsey....	..	..	..	..	..	..	..	90	..	140	107	74	..	..
Average 1888	137	..	127	156	(149)	121	137	121	139	161	128	99	76	118
„ 1887	136	182	103	168	58	106	126	101	134	153	135	75	69	115
„ 1886	142	..	108	173	65	84	117	113	131	160	130	85	74	118
„ 1885	141	..	90	161	53	105	116	107	133	156	137	96	63	(74)
„ 1884	143	183	97	151	56	90	115	101	136	155	118	..	62	97
„ 1883	140	(180)	104	169	39	106	112	102	135	156	131	..	86	..

[1] Hatching.

South of England; the deficiency was considerable in February, March, April, and June, and enormously so in July. The amount of accumulated temperature below 42° was generally above the mean, especially in February; in some districts it was slightly below the mean in January, April, and May. Sunshine was slightly above the mean in January, but far below it in March, June and July; and whilst January and February were dry, March was wet, and June and July especially so.

Under these circumstances vegetation was generally backward throughout the season. In the South-west of England and South of Ireland plants were earlier than usual, but not elsewhere. In February they were from one to four weeks later, and gradually gained ground till June. In the South of Ireland they were slightly in advance of the average in June and July; in the South-west of England they just reached the average in July, whilst in Guernsey they were a fortnight later.

Fruits generally were a failure; very few really ripened, and from want of sun were deficient in flavour. Haymaking was unusually late (as much as

five weeks); it began in July or August, and was not entirely finished till late in September; much of the hay was spoilt or secured in poor condition. Straw was plentiful, and though the corn was not an average crop, the fine October enabled farmers to secure a better harvest than could have been expected.

Roots were often a failure, and potatoes were much diseased.

DISCUSSION.

THE PRESIDENT (Dr. Marcet) said that this report came most opportunely after Mr. Harding's paper, as it served to illustrate the effect of the persistent cold on vegetation.

Mr. BALDWIN LATHAM said it was most remarkable that, despite the sharp frosts recently experienced, a large number of plants in the southern suburbs of London were then in flower. The ground temperature was much higher at the present time than was usually the case, and if it continued high there was every prospect of an early spring.

Mr. MAWLEY said that he regarded these Phenological Reports as both valuable and interesting, and regretted that the author had this year sent in such a very short one. From a horticulturist's point of view, last summer was a very disappointing one, being so short, cold, wet and sunless. It was surprising to see primroses and other spring-flowering plants blossoming so freely until quite recently. No doubt the cool wet summer had kept them growing, and the mild weather experienced during the last month had caused them to come thus prematurely into flower.

A WINTER'S WEATHER IN MASSOWAH.

By CAPT. DAVID WILSON-BARKER, F.R.Met.Soc., F.R.G.S.

[Received November 3rd—Read December 19th, 1888.]

SUMMARISED results of a series of good observations taken during any consecutive time at a place where no regular observations have hitherto been made are valuable, as from a collection of such results taken by several observers an approximate notion may be formed as to the climate of the place. In the following paper I shall endeavour to give such a result, reduced from observations taken during the months of December 1887, January and February 1888; and although the paper must necessarily be statistical, yet I hope it may be of some use and interest, as it is under but few circumstances that such a series of observations—taken as they were day and night at regular intervals of two and four hours—can be placed before the Society. Again, the stability of the weather in places situated as Massowah is, warrants the preparation of a paper of this description, as the yearly differences are comparatively slight and observations for one season are likely to give a fairly good approximation for the same season at another time. The paper will also give some idea of the weather in a district of which we have heard a good deal lately in connection with the Italian Expedition there. It will first be necessary to give a short description of the place of observation and its

surroundings, as upon these the relative value of the observations so much depends.

Massowah is situated in latitude 15° 37′ 2″ N, longitude 39° 27′ E, and is therefore well within the tropics, and is on the western edge of the Red Sea, up and down which a monsoonal North or South wind continually blows. On its North, East and South-east is the sea, to the North-west and West stretches a barren sandy plain bounded by rocky hills and mountains, while on the West, South-west and South lies the rocky mountain table land of Abyssinia. The ship on which these observations were taken was moored in Ierrar Bay—one of the two indentations which form the harbour of Massowah —a small inlet, just large enough to hold the ship, and situated half a mile from the sea. For a distance of three miles the plain all round is level and almost barren, and at that distance to the Westward are the first hills by the village of Makullo, from thence inland there are a succession of hills rising in altitude from 500 feet at Makullo till the mountain ranges of Abyssinia are reached, attaining there an altitude of 10,000 feet. For a more detailed description I would refer to a short paper in *Science Gossip*, of October 1888.

The position of the instruments on board the ship was fixed on after a good deal of consideration, nor do I think a better position could have been found. The instruments were of the usual form supplied for use at sea, and, with the exception of the anemometer, rain-gauge and spectroscope,were lent by the Meteorological Office, which is a sufficient guarantee of their accuracy; all corrections are applied excepting only that for gravity in the barometer, which I think better omitted at the present time. From 6 a.m. to 10 p.m. the observations (with a few exceptions) were taken by myself; for the night observations I am indebted to the able assistance of my second and third officers, Messrs: Lever and Boothby. In treating the observations it is as well to take them in the order in which they are tabulated in the Log supplied from the Meteorological Office.

1. *Wind.*—As may be expected, the phenomena of the land and sea breeze were well marked, and the direction of the wind at any given time might almost always be safely predicted. The following may be taken as a general description of the wind phenomena for December. From 9.30 p.m. wind backing to Westward, very light but freshening towards 4 a.m., decreasing again till 9.30 a.m., at which time it was generally very light and alternated with calms; towards 10 a.m. it began to freshen and veer to North-eastward, reaching its maximum force about 2.45 p.m., and was then well from the Eastward (sea breeze), decreasing in force and backing again to West-north-west towards 9.30 p.m.

This succession of the winds was practically the same for the months of January and February, except that in January the 9.30 a.m. veering was less rapid, and the sea breeze not so much from the Eastward, and the backing in the evening into the land breeze was a little more rapid. In February the commencement of the backing of the wind in the evening occurred a little earlier, about 7 p.m.

The general means for the months are given in Table I. as follows:—

TABLE I.—Wind.

Month.	Land Breeze.		Sea Breeze.	
	Direction.	Velocity.	Direction.	Velocity.
		Miles per hour.		Miles per hour.
December	W ¼ N	4·0	NE ¼ E	8·6
January	W ¼ N	4·4	NE ¼ N	7·2
February	WNW	4·7	NE	8·8

Though, as a general rule, the wind always backed, yet there were occasions in which it went round by South; North and South winds were rare, and when they did blow, were of short duration.

The velocity of the wind was measured with the Russell-Robinson wind gauge described in my paper on "The Force of Wind at Sea," *Quarterly Journal*, Vol. IX., p. 241, and if not exactly accurate absolutely, yet the comparative velocities of the wind are, and I have reasons for believing the absolute mean velocities are not far out. Care was always taken in recording the observations to hold the instrument in an exposed position.

Perhaps here I may be allowed to call attention to the great desirability of having a small anemometer, similar to such as mine, for use on board ship, more especially in cases where the observations are left to be taken by the officers, as is generally done, the wind velocities would then be intercomparable. It has been suggested to me by Mr. Ellery, F.R.S., that the tube of a Hagemann gauge might be run up a mast and connected at the bottom with a delicate pressure gauge, and it seems possible that this would give very fair results, though I have had no opportunity of testing it.

2. *Barometer.*—Undoubtedly, the most striking instrumental regularity is shown in the rise and fall of the barometer; but this regularity in tropical places is so well known, that I shall at once pass on to give, in Table II., the times of maximum and minimum for the different months.

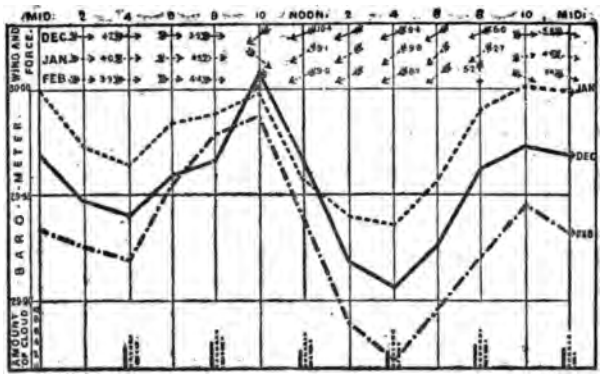
TABLE II.—Barometer.

Months.	Means.	1st Min.	1st Max.	2nd Min.	2nd Max.
	Ins.				
December	29·954	3.20 a.m.	10.0 a.m.	3.33 p.m.	9.25 p.m.
January	29·974	3.28 a.m.	10.0 a.m.	3.6 p.m.	9.48 p.m.
February	29·929	3.36 a.m.	9.33 a.m.	4.0 p.m.	9.47 p.m.

The mean monthly curves for December and February are more irregular than is the curve for January, which latter month also shows less range in altitude.

The barometer was fixed in the after deck-house, 12 feet above the sea-level.

8. *Dry and Wet Bulbs, Vapour Tension, and Relative Humidity.*—Under this head we treat of the most important factor in the weather of Massowah, as these, more than any others, determine the suitability of a place for habita-



Barometer, Wind and Cloud at Massowah.

tion by man. In a general way we think of Massowah as one of the hottest places in the world, and that it is so I have no doubt in my own mind, though I am somewhat sceptical as to the accounts given of the very high temperatures registered. What is really so trying about a place of this sort in summer is the continual heat day and night, when the air is heated up to a temperature above that of the blood, making it difficult to breathe.

TABLE III.—Temperature and Humidity.

Months.	Temp. in Shade.			Vapour Tension.					Relative Humidity.		
	Mean.	Max.	Min.	Mean.	1st Max.	1st Min.	2nd Max.	2nd Min.	Mean.	Max.	Min.
	°	P.M.	A.M.	In.	A.M.	A.M.	P.M.	P.M.	o/o	A.M.	P.M.
December	79·0	0.40	3.13	·784	8.0	4.0	8.0	3.46	79·2	4.0	3.27
January	76·8	2.26	4.0	·732	0.0	None	None	2.17	79·4	4.40	2.8
February	77·6	1.22	5.21	·734	8.0	4.0	8.0	0.33	78	4.0	1.32

The greatest shade temperature, 95°, was noted on February 28th, at 2.30 p.m., and the lowest, 68°·1, on February 2nd, at 4 a.m. Generally speaking, the coolest time was the last fortnight of January and the first fortnight of February, during which the vegetation and insect life on shore were at their best.

The thermometers were hung in the ordinary wall screen, and faced West by North. Close by was set up a Stevenson screen, in which the thermometers faced North by East; the readings of the two sets of thermometers were, for all practical purposes, the same, and gave a good opportunity for comparing the relative values of the two screens. I am inclined to favour—even in the hottest places—a perfect exposure for the screens, provided the radiation from beneath is reduced to a minimum.

4. *Solar Radiation.*—Observations of the black-bulb thermometer were taken at 8 a.m., noon, and 4 p.m., giving the following means:—for Decem-

ber 111°·8, January 101°·6, and February 114°·4. The thermometer was well exposed, and had its bulb directed to the South-east.

5. *Clouds.*—By far the most common cloud was a middle layer *stratus*, having an almost constant movement from a South-easterly point; next came the *cumulus*, generally moving with the wind, and then the *cirrus* always moving from a South-west point.

Table IV. shows the mean cloudiness.

TABLE IV.—Amount of Cloud.

Months.	Mean Amount of Cloud.	1st Max.	1st Min.	2nd Max.	2nd Min.
December	3·5	8.0 a.m.	4.0 a.m.	8.0 p.m.	2.47 p.m.
January.....	6·3	6.46 a.m.	0.0 a.m.	7.33 p.m.	10.40 a.m.
February	4·2	8.0 a.m.	0.0 a.m.	8.0 p.m.	4.0 p.m.

6. *General Weather* was fine, though at this season thunderstorms and squalls sometimes occur. On the evening of our arrival, November 25th, there was a thunderstorm, accompanied by rain and very unsteady wind, for three hours.

7. *Sea Surface* was generally calm, though with strong South-easterly wind a nasty swell rolls right into the harbour. Observations of the tides were taken, but owing to the difficulty of getting observations only very approximate results could be obtained. These showed the rise and fall to be very irregular, and having an extreme average range of 8 feet 5 inches. I had hoped to detect some connection between the tide movements and the general meteorological conditions, but failed to do so, though it is possible there may be some slight and unimportant relations. I might suggest that there are probably important relations between the growth of the coral and the impinging of the tidal currents on the fringing reefs, as in some places the edge of the reef is quite close to the land, while in other places it runs out for some distance.

The diurnal changes in the temperature of the sea were remarkably regular. Table V. gives mean temperatures, maxima and minima. The

TABLE V.—Sea Surface Temperature.

Months.	Mean.	Max. at	Min. at
	°		
December	83·1	5.54 p.m.	7.20 a.m.
January	80·8	5.9 p.m.	8.0 a.m.
February	80·8	5.41 p.m.	8.0 a.m.

mean density of the water was 1·0265, which is not by any means high for a sea in which such an evaporation goes on, surrounded as it is by sandy deserts.

8. *Rainfall.*—Having no rain-gauge with me, one was extemporised out of a meat tin, in the top of which was carefully fitted a funnel, and over the

bottom was a layer of pitch. This was then fitted in a rack, over the Stevenson screen and about 21 feet above the sea surface, and well exposed. Observations were taken daily at 8 a.m., but unfortunately, owing to sickness, I had to discontinue the observations for the first ten days of February, but was able during that time to record the times of rainfall. Table VI. gives the amount of rainfall and the number of days it fell.

TABLE VI.—Rainfall.

Months.	Rainfall.	No. of Days of Rain.
	In.	
December	1·00	6
January..... ...	1·85	14
February	1·03[1]	7

9. *Spectroscope* observations of the rain band were made every day; using a Browning miniature spectroscope at 7 a.m., looking North-west, the instrument being elevated about 80°, and using a scale of 0 to 8, I find it quite impossible to distinguish more grades of shading. It certainly is a valuable instrument in forecasting rain, but there will be some difficulty in getting a scale of relative values for its reading.

In conclusion, it will be interesting to glance over the chart of daily instrument curves, and note the relations they bear to one another. If we look along the curves, we shall see all through the general daily fluctuations that there are also periods when the lines are above the mean and times when they are below approximately, the times of fluctuation are as follows:—

Barometer	6½ days.	Sea Temperature	12 days.
Temperature, Air	6½ ,,	Wind Force	12½ ,,
Vapour Tension	7½ ,,	Cloudiness	12½ ,,
Relative Humidity	8½ ,,		

I have no doubt that for a long series of observations taken in such a place as this we might determine a certain period of fluctuation which would be common to all observations, and would show their relation to each other. The concentration of the maxima and minima at certain hours of the day is well shown in the monthly mean chart, on which the maximum and minimum symbols were plotted from curves carefully projected.

[1] The amount actually registered was 0·63 in., and estimated amount 0·4 in. for the first ten days. I was informed, by old residents, that the rainfall was about the average, and from this it would appear that if reservoirs were made for storing the rain there would be no need of condensing the sea water; in addition, arrangements might be made to irrigate the rich alluvial soil spread over the plain, the presence of which is a sign that there either are or have been very heavy rains in this district.

MEANS FOR THE MONTHS OF DECEMBER, JANUARY AND FEBRUARY.

Observation.	Month.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Midnt.	Mean for Month.
Barometer corrected	December	Ins. 29·946	Ins. 29·940	Ins. 29·961	Ins. 29·966	Ins. 30·007	Ins. 29·967	Ins. 29·919	Ins. 29·909	Ins. 29·926	Ins. 29·963	Ins. 29·974	Ins. 29·969	Ins. 29·954
	January	·972	·963	·983	·988	29·999	·957	·941	·937	·955	·990	30·001	·999	·974
	February	·925	·919	·956	·980	·989	·940	·891	·872	·885	·922	29·945	·934	·929
Wind	December	N 84° W	N 87° W	N 87° W	N 79° W	N 37° E	N 59° E	N 61° E	N 56° E	N 42° E	N 62° E	W	N 81° W	N 10° W
Force	"	..	4·2	..	3·9	..	10·4	..	9·4	..	6·0	..	3·8	6·3
Wind	January	N 86 W	S 88 W	S 88 W	S 88 W	N 34 W	N 37 E	N 51 E	N 39 E	N 30 E	N 34 E	S 81 W	N 76 W	N 41 W
Force	"	..	4·0	..	4·5	..	9·1	..	9·8	..	2·7	..	4·6	5·8
Wind	February	N 82 W	N 83 W	N 82 W	N 85 W	N 17 E	N 65 E	N 53 E	N 51 E	N 39 E	N 3 W	N 58 W	N 61 W	N 33 W
Force	"	..	3·9	..	4·4	..	9·0	..	8·7	..	5·2	..	5·4	6·1
Temperature in the Shade	December	..	76°3	..	79°2	..	79°9	..	80°5	..	80°0	..	78°0	79°0
	January	..	74·6	..	76·3	..	78·2	..	78·4	..	77·7	..	75·8	76·8
	February	..	74·9	..	76·3	..	79·3	..	79·5	..	78·4	..	77·1	77·6
Amount of Cloud	December	..	3·5	..	4·5	..	2·8	..	2·2	..	4·1	..	3·8	3·5
	January	..	5·9	..	6·6	..	5·9	..	6·7	..	7·0	..	5·6	6·3
	February	..	4·3	..	5·1	..	4·8	..	3·7	..	4·4	..	3·2	4·2
Sea Temperature	December	..	82°9	..	82°2	..	82°8	..	83°9	..	83°8	..	83°1	83°1
	January	..	80·5	..	80·0	..	80·6	..	81·4	..	81·3	..	80·9	80·8
	February	..	80·2	..	79·9	..	80·8	..	82·0	..	81·7	..	80·5	80·8
Relative Humidity	December	..	o/o 85·2	..	o/o 80·4	..	o/o 76·3	..	o/o 72·1	..	o/o 78·5	..	o/o 82·5	o/o 79·2
	January	..	85·6	..	81·7	..	74·5	..	73·0	..	78·4	..	83·0	79·4
	February	..	87·3	..	80·3	..	70·4	..	71·5	..	77·9	..	80·8	78·0
Vapour Tension	December	..	In. ·778	..	In. ·804	..	In. ·777	..	In. ·753	..	In. ·800	..	In. ·794	In. ·784
	January	..	·737	..	·737	..	·717	..	·715	..	·742	..	·745	·732
	February	..	·731	..	·735	..	·702	..	·723	..	·758	..	·757	·734

DISCUSSION.

THE PRESIDENT (Dr. Marcet) said that communications from travellers were always of great interest and very valuable. He enquired whether Capt. Wilson-Barker had been able to ascertain the amount of terrestrial radiation during the night-hours. He supposed it would not be much as the air was rather damp, and the tension of vapour did not appear to be very much different during the night-time to what it was in the day. The winds experienced at Massowah were much the same in their general direction and changes as those which blew along the south coast of France on the shores of Mediterranean Sea.

Mr. BAYARD said that the deposits of rich alluvial soil in the district of Massowah were probably brought down from the mountains further inland by the little streams which flowed from them. He thought it would hardly be practicable to store the rain which fell, for the amount was so small and the heat so great that it would be speedily evaporated.

Mr. HARRIES said that the results of the observations made by the Italian Expedition at Massowah during two and a half years, seemed to show that the rainfall registered by Capt. Wilson-Barker was greater than that measured in previous similar periods.

Mr. BALDWIN LATHAM said it was quite possible that, although the heat was great, the amount of evaporation might be comparatively small, seeing that the air was so damp. Evaporation was not always greatest when the weather was hottest; as in England, August was by far the hottest month, but it was not as a rule the month of greatest evaporation.

Mr. SCOTT said, regarding the question of evaporation, that the relative humidity was shown by Capt. Barker's tables to be above 80 per cent. during the night, and about 72 per cent. or 73 per cent. in the day hours. Massowah was considered by Dove to be the hottest place in the world in May. He said in his *Klimatologische Beiträge*, Vol. I. p. 57. "May in Massowah is 29°·78 R. (99°·1 F.), the highest monthly mean I know of."

Mr. MAWLEY said that it was interesting to note the degree of accordance between the two wooden screens, and thought that it tended to show that the Stevenson screen could be used in any climate.

Capt. WILSON-BARKER, in reply, said that the two screens he used had no shade of any kind, but were fully exposed to the sun's rays. No observations on terrestrial radiation were made. Regarding the question of water supply, water could be readily obtained by digging in the river beds, showing that a good deal of rain must have fallen some distance inland.

INSOLATION.

By RUPERT T. SMITH, M.Inst.C.E., F.R.Met.Soc.

(Abstract.)

[Received December 13th, 1887.—Read April 18th, 1888.]

In this paper the author aims at giving a ratio of measurement for the intensity of the sun's rays, irrespective of the angle of incidence and of the duration of sunshine, by a series of curves (not printed here) drawn to show the insolation for the year, *i.e.* the solar radiation as usually deduced from maximum air temperature in comparison with the readings of the black bulb thermometer *in vacuo*.

No account is here taken of the physical effects of absorption, radiation (other than direct), refraction, or polarisation of the ray on its passage to the earth, other than is shown by the results of instrumental observation.

It is best to ascertain the simple effects first, and then to add the various and delicate calculations necessary to investigate the whole subject.

The values are therefore given both without and with the effects due to the sun's altitude; the chief complications met with being the greater diathermancy of the air in spring, due to the dryness of the seasons and the prevalence of East wind—and again the fact that solar radiation is greater in the morning than in the afternoon, and that earth radiation is greater in the evening than after midnight.

The author recommends great caution in drawing conclusions as to the final value of sun-heat received by the earth, and he refers to a former paper of his (*Quarterly Journal*, Vol. XII. page 180) for an estimate of the values of solar radiation for 1875-1884, as observed in the neighbourhood of Birmingham, in which paper the effect of aqueous vapour, cloud and wind upon solar radiation was discussed. The author has now tabulated the results as shown in Table I.

The author considers the ordinary observations of solar radiation as complex

TABLE I.—Solar Radiation.

	Jan.	Feb.	Mar.	April.	May.	June.	July.
Sun's Mean Altitude	° ′ 16·36	° ′ 24·34	° ′ 35·51	° ′ 47·20	° ′ 56·39	° ′ 60·35	° ′ 58·51
Air Temperature—Mean	° 36·2	° 38·5	° 39·9	° 45·5	° 51·1	° 58·1	° 61·1
Solar Radiation—Uncorrected	13·7	26·4	39·3	44·0	44·0	43·4	41·6
Corrections for Differences:—							
In time of Maxima	+1·8	+2·2	+2·7	+3·1	+3·2	+3·5	+3·4
Open to Closed Screen	— ·7	— ·9	— ·9	— ·9	— ·9	— ·7	—1·1
Mean Maximum Solar Radiation	36	47	60	61	58	56	55
Absolute highest ,,	49	56	78	67	64	60	60
Extreme Daily Range ,,	34	24	35	19	13	13	14
Terrestrial Radiation	° 3·1	° 3·6	° 3·5	° 3·8	° 3·9	° 3·9	° 4·6
Vapour Tension	·176	·217	·200	·235	·251	·325	·422
Relative Humidity	·848	·829	·782	·745	·730	·732	·782
Mean Amount of Cloud	6·9	7·4	6·1	6·4	6·1	6·0	6·5
No. of Overcast Days	18·4	15·9	12·7	13·1	10·8	9·1	10·1
No. of Storms	4·5	3·5	2·9	1·8	1·2	·7	·7

	Aug.	Sept.	Oct.	Nov.	Dec.	Means.
Sun's Mean Altitude	° ′ 51·12	° ′ 40·28	° ′ 28·32	° ′ 18·57	° ′ 14·23	° ′ 37·50
Air Temperature—Mean	° 59·6	° 55·0	° 47·4	° 40·8	° 36·6	° 47·5
Solar Radiation—Uncorrected	40·0	38·1	28·8	18·8	12·7	32·5
Corrections for Differences:—						
In time of Maxima	+3·3	+2·8	+2·3	+1·6	+1·4	..
Open to Closed Screen.....	—1·0	— ·7	— ·5	— ·6	— ·6	..
Mean Maximum Solar Radiation ..	56	54	48	43	35	51
Absolute highest ,,	68	71	54	61	66	63
Extreme Daily Range ,,	20	23	22	39	46	..
Terrestrial Radiation	° 4·5	° 4·7	° 4·2	° 3·7	° 4·0	° 4·0
Vapour Tension	·436	·379	·285	·224	·191	·2795
Relative Humidity	·792	·825	·848	·840	·886	·80325
Mean Amount of Cloud	6·9	6·0	6·4	6·3	6·4	6·4
No. of Overcast Days	12·2	10·6	14·2	12·0	12·4	12·6
No. of Storms	1·7	1·5	4·5	4·9	4·2	2·7

and insufficient, and is of opinion that there is little to be gathered from the peculiar result of the solar radiation of a year, with its May maximum and its continuously high radiation from April to October, instead of a maximum at or about the summer solstice and a fairly regular curve of radiation throughout the year. The author considers that on the whole the black bulb thermometer *in vacuo* holds its own with any other instrument used in actinometry.

All his own observations as recorded in this paper were made with one instrument.

Table II. gives the various figures all reduced to the same common denominator, and this (82°·5) is the figure for the mean solar radiation of the district under discussion (Birmingham) for the period 1875-1884. This figure is some 8° below the average, or 24 per cent. below the average of the country taking eastern and western stations together. The low figure is caused by the smoke of the district.

TABLE II. A.—In terms of Mean Solar Radiation (32°·5)—without Sun's Altitude.

	Jan.	Feb.	Mar.	April.	May.	June.
	°	°	°	°	°	°
Units of Intensity	24·1	28·3	32·5	36·3	39·2	40·8
Mean Temperature of Air	24·9	26·5	27·5	31·4	35·1	39·9
Black Bulb Thermometer, Mean	38·8	34·4	30·3	27·3	25·7	26·3
" " eliminated	38·0	36·2	35·3	32·2	29·8	27·2
Solar Radiation, correct for noon and Open Screen	28·9	37·1	38·8	34·8	30·7	29·4
Terrestrial Radiation	25·4	29·5	28·6	31·1	31·9	32·0
Phenomena influencing Radiation:—						
Vapour Tension	20·6	25·3	23·4	27·5	29·4	38·0
Humidity, Relative	34·4	33·6	31·7	30·2	29·6	29·7
Cloud, Mean	34·9	37·3	30·6	32·6	30·9	30·5
Cloud, Full	47·5	40·2	32·8	33·9	28·0	23·6
Cloudless Weather	33·8	44·3	38·6	30·8	26·1	24·6
Clear Sky	46·7	38·8	33·5	31·3	25·2	23·7
Wind	28·5	35·6	39·8	33·6	30·5	27·3
Storms	29·1	39·3	38·7	34·7	30·8	29·6
4 Phenomena Means correct (Curves 7-14)	34·8	36·8	33·4	31·7	28·8	28·6

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°
Units of Intensity	39·9	37·2	33·6	29·7	26·1	23·1
Mean Temperature of Air	41·7	40·9	37·7	32·4	27·7	25·1
Black Bulb Thermometer, Mean	26·7	28·6	31·7	35·2	40·8	45·0
" " eliminated	24·9	24·9	27·6	32·5	39·2	43·0
Solar Radiation, correct for noon and Open Screen	28·4	30·2	34·3	35·6	33·9	28·7
Terrestrial Radiation	37·7	37·7	38·4	34·4	31·4	32·7
Phenomena influencing Radiation:—						
Vapour Tension	49·4	51·0	44·3	33·4	26·2	22·3
Humidity, Relative	31·7	32·1	33·4	34·4	34·1	35·9
Cloud, Mean	32·7	34·8	30·3	32·2	31·7	32·3
Cloud, Full	26·1	31·6	27·4	36·7	31·0	32·0
Cloudless Weather	24·5	29·1	30·2	38·3	40·1	30·4
Clear Sky	23·2	23·9	26·9	33·9	46·0	37·7
Wind	27·1	30·9	32·7	36·2	36·5	32·1
Storms	28·5	29·8	33·9	33·6	33·8	29·0
4 Phenomena Means correct (Curves 7-14)	30·4	33·0	32·4	35·1	34·9	30·9

TABLE II. B.—In terms of Mean Solar Radiation (32°·5)—with Sun's Altitude.

	Jan.	Feb.	Mar.	April.	May.	June.
	°	°	°	°	°	°
Units of Intensity	11·0	18·7	30·2	42·4	52·0	56·5
Mean Temperature of Air	11·4	17·6	25·8	37·0	46·9	55·6
Black Bulb Thermometer, Mean	20·2	26·1	32·4	36·6	39·0	41·7
" " eliminated	19·8	27·2	36·8	42·0	44·1	42·6
Solar Radiation, correct for noon and Open Screen	13·0	25·8	39·3	44·3	44·5	44·4
Terrestrial Radiation	12·1	20·4	27·9	38·0	44·3	46·4
Phenomena influencing Radiation:—						
Vapour Tension	9·4	16·7	21·4	32·3	38·2	52·4
Humidity, Relative	17·0	24·2	32·1	38·8	42·9	44·7
Cloud, Mean	17·1	26·6	30·7	41·0	44·2	45·5
Cloud, Full	24·3	29·9	34·3	44·6	41·8	36·7
Cloudless Weather	17·3	32·9	40·4	40·5	39·0	38·3
Clear Sky	24·8	30·0	36·5	42·8	39·1	38·4
Wind	14·1	25·6	40·3	42·7	44·1	41·2
Storms	14·2	27·9	38·7	43·6	43·9	44·0
4 Phenomena Means correct (Curves 7–14)	17·0	26·5	34·3	40·9	41·8	43·2
Ratio of Diathermancy—Mean of Curves 4, 5 and 15	16·6	26·5	36·8	42·4	43·5	43·4
Terrestrial Radiation—Mean of Curves 6 and 15	14·3	23·5	32·3	40·2	43·9	44·9

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°
Units of Intensity	54·2	46·0	34·7	22·6	13·5	9·1
Mean Temperature of Air	57·1	51·0	39·2	24·8	14·4	10·0
Black Bulb Thermometer, Mean	41·7	40·6	37·4	30·6	24·1	20·4
" " eliminated	38·8	35·6	32·9	28·4	23·1	19·5
Solar Radiation, correct for noon and Open Screen	42·1	40·5	38·4	28·8	18·0	11·7
Terrestrial Radiation	53·7	48·9	41·5	27·3	17·0	13·5
Phenomena influencing Radiation:—						
Vapour Tension	65·6	62·6	45·1	25·4	13·1	8·6
Humidity, Relative	46·9	43·3	37·8	28·5	19·1	15·5
Cloud, Mean	47·9	46·5	33·7	26·3	17·6	13·7
Cloud, Full	39·9	44·0	31·8	31·3	18·0	14·2
Cloudless Weather	37·4	40·5	35·0	32·7	23·3	13·5
Clear Sky	36·9	34·6	32·4	30·1	27·8	17·4
Wind	40·2	41·7	36·7	29·9	20·5	13·8
Storms	41·6	39·6	37·6	28·7	18·7	12·3
4 Phenomena Means correct (Curves 7–14)	44·8	44·3	36·4	29·1	19·4	13·1
Ratio of Diathermancy—Mean of Curves 4, 5 and 15	41·9	40·1	35·9	28·8	20·1	14·8
Terrestrial Radiation—Mean of Curves 6 and 15	47·8	44·5	38·7	28·0	18·6	14·1

The proportionate gain of the radiation of both the sun and the earth is most in winter, and then in autumn, spring has a slight and summer a considerable loss. We appear to lose 20 per cent. in summer, and to gain 45 per cent. of the winter radiation, which is what we may expect, being then in perihelion. The sequential order of the months goes far to prove the accuracy of the figures. The net gain of radiation in the year in this latitude (52°30′ N.) would appear then to be about 6 per cent. (Table III.)

The greatest attention should be given to maximum values, for there are very few days in the year when unusual facilities occur for obtaining the highest

TABLE III.—With the Sun's Altitude and Duration of Radiation.

	Jan.	Feb.	Mar.	April.	May.	June.	July.
Ratio of Diathermancy	16·6°	26·5°	36·8°	42·4°	43·5°	43·4°	41·9°
Terrestrial Radiation	14·3	23·5	32·3	40·2	43·9	44·9	47·8
Duration of Radiation in terms of 12 hours:—							
Sun, day hours	7·8	9·6	11·7	13·7	15·6	16·6	16·1
Earth, night hours	16·1	14·4	12·5	10·4	8·3	7·2	7·8
Sun, Radiation and Duration ..	10·8	21·2	35·9	48·4	56·6	60·0	56·2
Earth, Radiation and Duration	19·2	28·2	33·7	34·8	30·4	26·9	31·1
Differences—Net Gain..	−8·4	−7·0	+2·2	+13·6	+26·2	+33·1	+25·2
Months in Order of Gain:— Sun and Earth together.....	10	9	6	4	2	1	3
Monthly Order, by percentages of gain (1) and loss (12):—							
Sun.....	2	4	6	8	10	12	11
Earth.....	3	4	7	9	11	12	10
Sun and Earth together....	3	4	6	8	10	12	11

	Aug.	Sept.	Oct.	Nov.	Dec.	Means.
Ratio of Diathermancy	40·1°	35·9°	28·8°	20·1°	14·8°	32·5°
Terrestrial Radiation	44·5	38·7	28·0	18·6	14·1	32·5
Duration of Radiation in terms of 12 hours:—						
Sun, day hours	14·4	12·5	10·5	8·3	7·2	12·0
Earth, night hours	9·6	11·7	13·7	15·6	16·6	12·0
Sun, Radiation and Duration....	48·1	37·4	25·2	13·9	8·9	35·22
Earth, Radiation and Duration..	35·6	37·7	32·0	24·2	19·5	29·44
Differences—Net Gain..	+12·5	−0·3	−6·8	−10·3	−10·6	= 5·78 p. ct.
Months in Order of Gain:— Sun and Earth together	5	7	8	11	12	..
Monthly Order, by percentages of gain (1) and loss (12):—						
Sun	9	7	5	3	1	..
Earth	8	6	5	2	1	..
Sun and Earth together	9	7	5	2	1	..

effect of solar radiation, and it would seem that we get proportionally higher effects at the winter solstice than at any time in the year.

There is no doubt that all the solar radiation figures of this paper are lower than they are elsewhere, especially during the cold months, when there is reason to believe that the denser air causes the smoke canopy to occupy less space.

Objection may be taken to the full number of hours of sunlight and of darkness being used (Table III.) where about one-third only of the sunlight and presumably the same proportion of the night effect are actually received, but

what is here put forth is not so much the working out of the process as the pointing out of a method by which radiation observation can be utilised hereafter to assist in the absolute measurement of sun-heat and the yearly storage of heat by the earth. The creation of a standard figure for the epoch of the observation of insolation would be a boon to the workers on this subject.

DISCUSSION.

THE PRESIDENT (Dr. Marcet) said that it was fortunate that the observations discussed were all made with the same thermometer, as the results were comparable throughout the series. He inquired what was the relation between the radiation given out at night and the heat received by the earth during the day, and at what time in the twenty-four hours equilibrium was restored.

Mr. SMITH said he could not say either at what hour of the day or season of the year equilibrium was restored, but he knew that in the spring-time the greatest intensity of radiation was early in the morning. So far as his calculations were concerned there is in the Birmingham district a gain of 67° in favour of the earth during the year. He considered that terrestrial radiation ought perhaps to have been more heavily handicapped in drawing the curves for his paper than it had been.

REMARKABLE HAILSTORM NEAR MONTEREAU, FRANCE, AUGUST 15th, 1888.

[Read November 21st, 1888.]

LAST summer we were voyaging on some of the French rivers in our outrigged boat, which we had sent from the Thames to Auxerre, whence we embarked to row and sail down the Yonne and the Seine. In the course of our voyage on August 15th we encountered a fearful storm of thunder, lightning, hail and wind on the River Yonne, between Sens and Montereau, only escaping disaster by taking shelter, just in time, in the Lock-house of the Ecluse de Barbey.

The preceding days had been excessively hot, and the morning of the storm was bright and sultry. About 4 p.m. clouds came up on all sides with thunder and lightning, the latter setting fire to a farm near the river. There was a violent wind with the hailstorm, the tempest lasting about twenty minutes.

Hailstones of tremendous size, about 7 inches in circumference, fell in thousands over a distance of about a mile and a half, whilst others of smaller size so covered the ground as to make it white. After the small hail had melted the big stones remained scattered on the river banks and fields at about two yards' distance from each other.

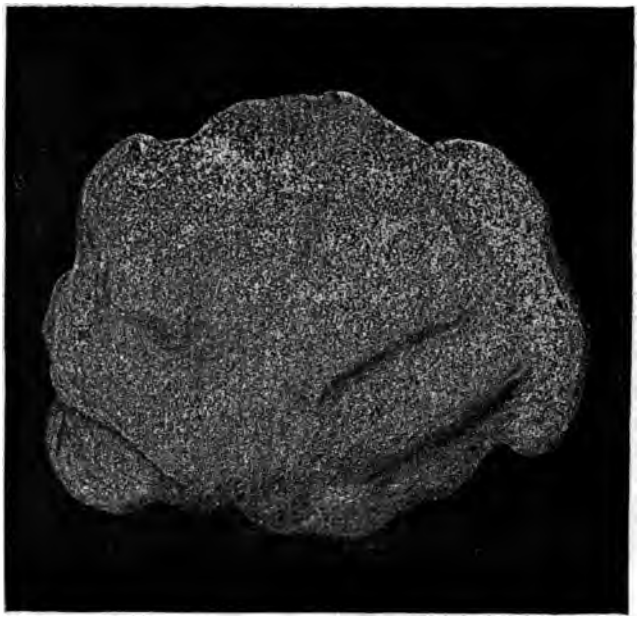


FIG. 1.

FIG. 2.

Sketches of Hailstones (Actual Size) which fell near Montereau, France, August 15th, 1888.

FIG. 3.

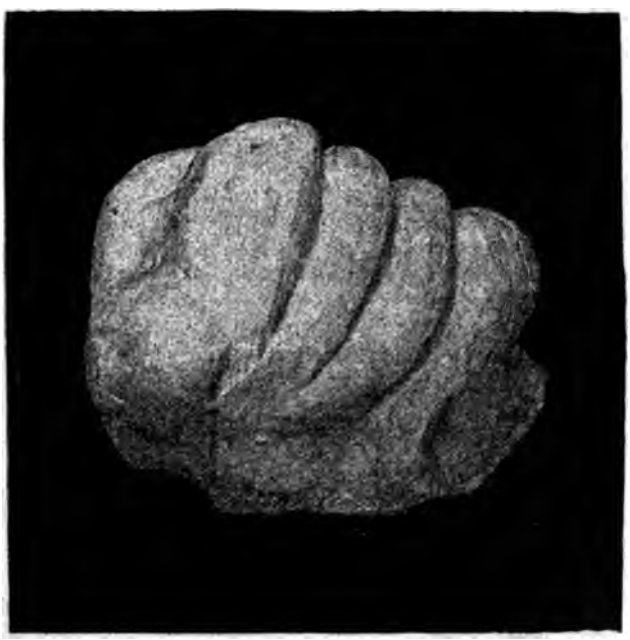


FIG. 4.

Sketches of Hailstones (Actual Size) which fell near Montereau, France, August 15th, 1888.

We made careful measurements and drawings of several of the large hailstones, from which we have prepared models showing the actual size and shape of the stones. Four of these are represented in the accompanying engravings (pp. 48, 49).

We should mention that the stones had been on the warm ground for quite half-an-hour before we picked them up and outlined them. They seemed so much colder than ordinary ice that they melted imperceptibly. Although the river bank and fields adjacent were studded with them, we saw none floating in the river; all appeared to have sunk, but the surface of the water was so covered with leaves and small branches cut from the trees by the storm, that we might have passed them unobserved.

A. C. STRATTEN.
W. B. M. BIRD.
A. JAMESON.
E. WHITEHORN.

ON THE MONTEREAU HAILSTORM.

(Translated from *La Nature* of October 6th, 1888.)

A FORMIDABLE hailstorm ravaged the environs of Montereau (Seine et Marne) on August 15th, 1888. The day was moderately hot, but stormy; a thick cloud, low down, formed in the South, burst suddenly on our fields, discharging hailstones of prodigious size. In a few minutes—not more than five or six—roofs were perforated, great branches were knocked off the trees, and holes were dug in the soil 3 or 4 inches deep, at intervals of one or two feet, as though by cannon shot. Many of these extraordinary hailstones weighed 260 grammes (more than 9 ounces avoirdupois), and were kept two or three days. They were generally spheroidal in shape, with, in some cases, rounded protuberances, the nucleus being in some opaque and in some transparent.

Continuing slowly its narrow but devastating course, the hail cloud visited the communes to the north of us, Milly, and others; but there, for some inexplicable reason, the phenomena were different, the stones being smaller but more numerous, not merely broke the branches of the trees, but stripped them of their leaves, and cut up even the smallest plants.

The repairs of the roofs of the Chateau and farm are far from being completed, yet we have already used up 80,000 tiles and 25,000 slates. I leave you to guess the number of windows, garden frames, bell-glasses, &c. which have been broken.

COMTE DULONG DE ROSNAY.

DISCUSSION.

Mr. MARRIOTT read the following accounts of some occurrences of large hailstones which had fallen in the British Isles:—

1697, May 4th. Hailstones measuring 14 inches in circumference fell in Hertfordshire and killed several persons. (*Thomson's Introduction to Meteorology*, p. 179.)

1784, June 5th. At Selborne hail was found measuring 3 inches in circumference. (*Natural History of Selborne*, lxvi.)

1808, July 15th. Masses of ice having a perimeter of 3 to 9 inches fell in Gloucestershire. (*Howard's Climate of London*, Vol. II. p. 50.)

1811, June 8th. A hailstone measuring 6·5 inches in diameter, and cuboidal, fell near Birmingham. (*Thomson's Introduction to Meteorology*, p. 179.)

1818, July 24th. Hailstones as large as a goose-egg, mixed with masses of ice, fell in the Orkney Islands. (*Trans. Roy. Soc. Edin.* Vol. IX. p. 187.)

1828, August 9th. Pieces of ice, some of which measured 3 inches long and 1 inch broad, fell at Horsley, Staffordshire. (*Edin. Jour. of Science*, Vol. IX. p. 354.)

1835, June. Hail measuring 3 inches in circumference fell near Edinburgh. (*Thomson's Introduction to Meteorology*, p. 181.)

1846, August 1st. Hail weighing 1 to 2 ounces, avoird., fell in London. (*Thomson's Introduction to Meteorology*, p. 181.)

1878, August 3rd. Ashby Parva, Lutterworth. The Rev. W. Clement Ley writes:—"Having to attend to the condition of my deluged house, and having a service in the church at 6.30, I was unable to weigh or take measurements of the hailstones until 8 p.m., when I found the stones to be in all cases exceptionally round and hard. I measured some, which were just 4½ inches, and one which was 5½ inches, in circumference. This was two hours after they fell." (*Symons's Meteorological Magazine*, Vol. XIII. p. 119.)

1879, August 2nd-3rd. At Richmond "a hail bolt which fell through a carpenter's window was found by him to be 4½ inches in length." (*Symons's Meteorological Magazine*, Vol. XIV. p. 100.)

1883, July 3rd. In North Lincolnshire the hailstones were in fact solid masses of ice of various shapes and sizes, weighing from 2 to 6 ounces, and some measured 6 inches in circumference. (*Meteorological Record*, Vol. III. p. 38.)

Mr. WHIPPLE said that he was an eye-witness of the hailstorm at Richmond on August 2nd and 3rd, 1879. It occurred about midnight, and he was awakened by the smashing of the glass in a small conservatory at the back of the house. He measured the pits made in the lawn by the falling hail the next morning, and found them to be about 2 inches deep. A copper roof was very much pitted, the dents remain to the present day. He also found a piece of glass embedded in the paint 10 feet away from the window. Ninety panes of glass were broken in the Kew Observatory, and in the conservatories of a gentleman (Mr. Cave) in the neighbourhood, which covered a quarter of an acre, not a pane of glass was left unbroken.

Mr. WILSON inquired whether these large hailstones were a conglomeration of smaller ones.

Mr. LATHAM inquired whether any sections of the hailstones had been made.

Mr. BIRD replied that no sections were made. The stones were so hard and solid that none of them appeared to split or break to pieces, though striking the ground with such violence.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

NOVEMBER 21ST, 1888.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

AUGUSTO ARCIMIS, Director of the Instituto Central Meteorologico, Madrid;
JOHN WILLIAM HORACE GRAY, Greville Lodge, Twickenham;
JAMES LARDNER GREEN, M.D., Harcourt Terrace, Salisbury;
RICHARD THOMAS MORGAN, Wellington House, Clevedon;
CHARLES EDWARD MUMFORD, 19 Ivanhoe Road, Sefton Park, Liverpool;
EDWARD LAVINGTON OXENHAM, F.R.G.S., British Consul, Chinkiang, China;
ALEXANDER MILNER ROBERTSON, M.D., Roehampton, S.W.;
EDWARD COX SEATON, M.D., 35 George Street, Hanover Square, W.;
JAMES NASMYTH SIDEBOTHAM, Erlesden, Bowdon, Cheshire; and
THOMAS COKE SQUANCE, M.D., F.R.M.S., 4 Beauclerc Terrace, Sunderland,
were balloted for and duly elected Fellows of the Society.

The following Papers were read, viz. :—

"RESULTS OF AN INVESTIGATION OF THE PHENOMENA OF ENGLISH THUNDER-STORMS DURING THE YEARS 1857-59." By G. J. SYMONS, F.R.S. (p. 1.)

"NOTES ON THE MEETING OF THE INTERNATIONAL METEOROLOGICAL COMMITTEE AT ZURICH IN SEPTEMBER 1888." By ROBERT H. SCOTT, M.A., F.R.S. (p. 13.)

"A METHOD OF PHOTOGRAPHING CIRRUS CLOUDS." By DR. A. RIGGENBACH. (p. 16.)

MR. A. C. STRATTEN exhibited some models of very large hailstones—spheres about 2½ inches in diameter—which fell near Montereau, on August 15th, 1888. (p. 47.)

DECEMBER 19TH, 1888.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

GEORGE ADKINS, L.R.C.P., Yealmpton, Plympton;
THOMAS NAISH BLAKE, Bramley House, Anglesey, Gosport;
CHARLES JOHN BROMHEAD, The Close, Lincoln;
ARTHUR NEWSHOLME, M.D., 15 College Road, Brighton;
EDWARD PAGET THURSTAN, B.A., M.D., 17 Park Road, Southborough, Tunbridge Wells;
REV. JOHN TURNER WILKINSON, M.A., LL.D., Swalcliffe Vicarage, Banbury; and
FREDERICK MANN WILLIAMS, L.R.C.P., Tavistock,
were balloted for and duly elected Fellows of the Society.

MR. J. S. HARDING and MR. H. S. WALLIS were appointed Auditors of the Society's Accounts.

The following Papers were read :—

"NOTE ON THE PROLONGED SPELL OF COLD WEATHER FROM SEPTEMBER 1887 to OCTOBER 1888." By CHARLES HARDING, F.R.Met.Soc. (p. 17.)

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1888." By the REV. T. A. PRESTON, M.A., F.R.Met.Soc. (p. 25.)

"A WINTER'S WEATHER AT MASSOWAH." By CAPT. D. WILSON-BARKER, F.R.Met.Soc. (p. 35.)

CORRESPONDENCE AND NOTES.

MEETING OF THE ITALIAN METEOROLOGICAL SOCIETY AT VENICE, SEPTEMBER 14th-21st, 1888.

THE third triennial General Meeting of the Italian Meteorological Society was held at Venice from September 14th to 21st, and was very successful. All the political and municipal authorities did their best to make the meeting pleasant and agreeable. The meetings and the conferences were held in the rooms of the Istituto Musicale Benedetto Marcello. The opening and closing meetings were held with great solemnity in the historical saloon of the Pregadi in the Ducal

Palace, in the presence of the members of the International Congress on Copyright, of the political, civil, military authorities, &c. H. M. the King was represented by the Prefetto of Venice; many Ministers and Academies and Societies were also represented. The members who responded to the call for this meeting were 170, of whom 104 were present.

The scientific programme, which contained sixty different questions for discussion, was divided into four branches:—

1. General Meteorology and Climatology.
2. Agricultural Meteorology and Phenology.
3. Hygienic Meteorology and Hydrology.
4. Geodynamics.

Among the most important subjects which were treated and discussed were the following:—

General Meteorology and Climatology.—The recent studies and the new experimental researches of Prof. Luigi Palmieri on the origin of atmospheric electricity; The results of the magnetic observations made at 103 stations in Italy; Results of the meteorological observations which are made on board the steamers of the Italian General Steam Navigation Company and of the Veloce Company at the request of the Meteorological Society (especially the observations made during 43 voyages in 1887); Examination of the meteorological observations made at 8 different stations belonging to the Company in South America and in Bengasi; Heliophotometric observations made by Prof. Craveri, of the Observatory at Bra, from 1874, with an instrument of his own invention; Two important papers by Prof. Busin, of Rome, on the distribution of temperature in Italy, and the high and low pressure in the northern hemisphere; and that by Prof. Ragona, of Modena, on the daily range of temperature; A paper by Padre Giovannozzi on the transparency of the air as observed by means of telescopes, and of its relations to meteorology; and two papers by Prof. Galli, of Velletri, and Prof. Golfarelli, of Florence, on the velocity of the wind, and on lightning conductors. Prof. Roberts described a new and very ingenious hygrometer made by Prof. Pizzarello, of Macerata, and several Directors of Observatories read reports of the work done, and the results they had obtained.

A discussion took place on the most efficacious way of increasing the interest for Meteorology in Italy by means of publications and lectures.

Agricultural Meteorology.—Padre Ferrari read an important paper on the present condition of meteorology as applied to agriculture, and on the steps which the government ought to take in this direction; and Count da Schio gave an account of the developement of phenological observations in Italy.

Hygienic Meteorology and Hydrology.—A long and important discussion took place on the order and classification of the climatic stations. Reports were read from the meteoric-hygienic observatories established under the auspices of the Society and of the civic authorities in Naples, Turin and Padua. A report was read by Prof. Roster, of Florence, on the daily and systematic analyses which he had made of the carbonic acid and of the soil of Florence in 1886. A long discussion took place on the results obtained by Father Siciliani on the connection between the level of the water in ponds and the atmospheric pressure; and the Report of Prof. Bellucci, of Perugia, on the experiments which he had made on the salt contained in rain-water, was listened to with great interest.

Geodynamics.—Several papers were discussed with reference to this important branch of science, amongst others being a lecture by Padre Bertelli, of Florence, in which the theory admitting electricity to be the prime cause of earthquakes is discussed, showing its improbability. Afterwards Padre Denza read a paper on the violent earthquake of 1887, and a discussion took place on the seismo-meteoric observations made at the Observatory of Pozzuoli, established and maintained by Prof. de Luca. Regulations were adopted for a better order of seismic observations at the stations of the Society.

ABERCROMBY'S "SEAS AND SKIES IN MANY LATITUDES."[1]

THIS is a very interesting and readable book, and contains accounts of voyages to various parts of the world, some of which were out of the beaten tracks of ordinary travellers.

Mr. Abercromby's special object in making these voyages was to investigate the phenomena of the sky and weather in various parts of the world. The pages of this *Quarterly Journal* have from time to time contained papers by Mr. Abercromby on the observations of clouds, weather, &c. which he has made during his travels. These and many other meteorological phenomena which he observed are all noted in this book. The whole is put together in a narrative form with an account of the countries, people, &c, which the author visited. The work is divided into 23 chapters, which describe voyages to Canada, Egypt, Australia, Caledonia, Fiji, Among the Islands, In the Pacific, New Zealand, Rounding Cape Horn, within the Arctic Circle, Archangel, Cape of Good Hope, Mauritius, Ceylon, The Himalayas, In the Hills, Borneo, In the Jungle, Gomanton, Manila, In the China Seas, America, and Washington.

The book is nicely got up and printed, and is copiously illustrated.

GREELY'S "AMERICAN WEATHER."[2]

THIS is really a handbook of meteorology, from the point of view of weather, and with citations of facts taken in great measure from American sources; at least almost all the charts are of the distribution of phenomena over the United States.

The volume is an interesting one, and the points which distinguish it from ordinary handbooks of the science, are the chapters relating especially to the work of the Signal Office. These are the chapters respectively on Low Area Storms; Cyclones and Hurricanes; High Area Storms; Cold Waves and Blizzards; and on Tornadoes.

Gen. Greely gives the following list of principles which he considers to have been established in the practice of forecasting in the States.

"1. In case of doubt, and where the temperature is abnormally high or low, it is safest to assume that the temperature will tend to return to its normal and seasonal condition.

"2. When the winds along the Gulf coast, or Atlantic seaboard, have blown from the ocean for twenty-four hours, even if the cloud formations are not large, rain may be assumed, with considerable accuracy, to follow within the ensuing day.

"3. Whenever the United States is covered with a barometric pressure below the normal, and no sharply-defined storm centre is present, the chances predominate that existing weather conditions will drift slowly, and with slight changes, from the Mississippi Valley to the Atlantic coast.

"4. Whenever in uncertain conditions the barometer rises in the south-western part of the United States, the weather to the north and east will soon clear, without there are decided and obvious reasons to the contrary.

"5. Cyclonic storms which enter the United States to the westward of the Mississippi River rarely recurve to the eastward, but may be expected to pass inland and die out within the confines of the continent.

"6. Cyclonic storms, with paths entirely or largely in low altitudes in winter, may be expected to be followed by prolonged cold periods and severe cold waves for the country eastward of the Rocky Mountains.

"7. When precipitation in advance of a cyclonic storm centre is less than the average in any quarter, even though it be the path usually followed by such storms; it is best to predict that the centre will not move in the direction of deficient rainfall.

[1] *Seas and Skies in many Latitudes, or Wanderings in search of Weather.* By the Hon. Ralph Abercromby. London, 1888. 8vo. 447 pp.

[2] *American Weather.* By General A. W. Greely. 8vo. 288 pp. with 32 Engravings and 24 Charts. New York. Dodd, Mead & Co. 1888.

"8. Whenever temperature is a few degrees above the freezing point, slight changes of temperature should be predicted rather than a fall, unless conditions are very decided, and *vice versâ* when the temperature is slightly below freezing.

"9. Hurricanes should not be expected to decidedly control the wind circulation more than 100 miles, nor induce excessive rainfall more than 200 miles from the centre.

"10. Unless the barometric gradients are very steep, or the thermometric gradients very great in advance of an anticyclone, it should not be expected to pass over even low mountain ranges without material modifications of its force, so that cold waves to the eastward or southward of mountain ranges should be predicted with caution.

"11. When low areas deepen as they advance, the predictor should anticipate a corresponding increase both in the velocity of the cyclonic winds in easterly quadrants and in the translation of the storm centre."

We think that most of our readers will agree with us that in the statements of these principles there have been a number of saving clauses introduced so that no positive recommendation is made. Moreover, in 10, gradients are spoken of as "steep" and "great," but no numerical definition of these terms is vouchsafed.

One statement (on p. 269) as to the prediction of hoar-frost is capable of being tested here. The words are, "A safe and simple rule to follow when the temperature is about 50° or below, is to multiply the difference between the readings of the thermometer by 2·5, and when the sum thus obtained is subtracted from the reading of the dry thermometer it leaves the approximate degree to which the temperature of the air will fall the coming night, unless change of wind to a moister quarter or increase of cloudiness interferes."

Here again the author fails to say at what hour the readings of the dry and wet-bulb thermometers are to be taken, or what minimum temperature is to be predicted, that in the screen or on the grass.

In the matter of predictions of seasons we read at p. 270, "There are apparently good grounds for believing that general laws can be deduced by which for certain parts of the globe it will be possible, from abnormal distributions of atmospheric pressure, to predict for prolonged periods in advance the general character of the coming season, as warm or cold, and wet or dry. Unfortunately for America, it seems that, owing to the easterly drift of the atmosphere, the ultimate chances of such predictions are better for Europe and Asia than for this continent."

Inasmuch as the ultimate results of such predictions in the old continent have been as yet total failures, we must put the probable result for the United States as a minus quantity.

We notice a few slips; Reaumur's name is always spelt Reamer, and a name well known and much respected in this country appears as Sir James Glashier.

The text is illustrated by a number of engravings of instruments, &c., in addition to the charts. The execution of the cuts is very far from satisfactory.

FINLEY'S "TORNADOES."[1]

WE most of us know the criticism on Browning's Sordello, to the effect that the first and last lines of the poem are both false. They are respectively,

'Who wills may hear Sordello's story told,'

and

'Who would hath heard Sordello's story told.'

We might almost say as much of Lieut. Finley's treatise. He does not tell us what tornadoes are, and his chief recommendation for escaping them is to go into a cellar. He tells us that tornadoes generally appear in the South-east quadrant of a depression, and chiefly occur in the warmest season, and that they are found principally where currents of air of different temperatures come into collision.

The signs given for the approach of a tornado are:—

[1] *Tornadoes—What they are, and how to escape them; with practical suggestions for the protection of life and property.* By Lieut. John P. Finley. Washington, 1887.

1. The prevalence of Southerly winds, with a gradual but continued increase of heat and moisture.

2. The sudden appearance of ominous clouds, first in the South-west, and then almost immediately in the North-west and North.

A tongue of cloud then appears dipping down, and the tornado is formed. Lieut. Finley says that from the time you see this tongue of cloud, you have some 40 seconds to escape in which you can run 200 yards, and you must not run in any easterly direction. You must avoid trees or buildings, and if you cannot get under ground, fall flat on your face on the earth, with head to the east. The only absolute security is to be found in a tornado cellar. We submit that Lieut. Finley cannot be said to have fulfilled either of the undertakings in his title.

RECENT PUBLICATIONS.

AMERICAN METEOROLOGICAL JOURNAL. A Monthly Review of Meteorology, Medical Climatology and Geography. Vol. V. Nos. 6-8. October-December 1888. 8vo:

The principal original articles are :—The organisation of the Meteorological Service in some of the principal countries of Europe, by A. L. Rotch (19 pp.). The author in this paper gives an account of the service in Russia.—The influence of forests upon the rainfall and upon the flow of streams, by G. F. Swain (23 pp.). The author considers that the removal of forests tends to increase the violence of freshets, and to increase the ratio of the maximum to the minimum flow, which ratio is an index of the variability of the stream. But it is extremely doubtful whether it can be proved that the removal of forests decreases the total quantity flowing off; and the author refers to the difficulty of proving or disproving such statements.—Tornadoes and Derechos, by Dr. G. Hinrichs (20 pp.). The "derecho" is a powerfully depressing and violently progressing mass of cold air, moving destructively onward in slightly diverging straight lines, generally towards the south-east (in Iowa), with the storm-cloud front curving as the storm-lines diverge. The barometer bounds upwards and the thermometer falls greatly under the blow of this cold air of the upper strata suddenly striking the ground. The derecho will blow a train of cars from its track, unroof, overturn and destroy houses; but it does not twist the timbers into splinters and drive them firmly into the hard soil of the prairie like the tornado.—Diurnal cloud and wind periods at the Blue Hill Observatory during 1887, by H. H. Clayton (11 pp.). —Average velocities of low-area storms and upper air currents in the United States, by Gen. A. W. Greely (4 pp.).

ANNALES DU BUREAU CENTRAL MÉTÉOROLOGIQUE DE FRANCE, publiées par E. MASCART, Directeur du Bureau Central Météorologique. Année 1886. I. Mémoires. 4to. 1888.

This contains, among other information, the following articles :—Résumé des orages en France et de l'état de l'atmosphère pendant l'année 1885, par M. Fron (16 pp. and 20 plates).—Remarques sur les cartes synoptiques, par M. Rollin (30 pp. and 9 plates).—Etude sur la marche des phénomènes de la végétation et la migration des oiseaux en France pendant les années 1884 et 1885, par A. Angot (48 pp. and 8 plates).—Etude sur le climat de Saint-Martin-de-Hinx, d'après les observations de M. Carlier, par A. Angot (64 pp.). This is a discussion of 22 years' observations 1865-1886.—Sur la prévision du temps; conditions actuelles et moyens de l'améliorer, par L. Teisserenc de Bort (20 pp. and 11 plates).—Etude sur le climat de Hué (Annam), par Dr. Simon (16 pp.). The observations discussed in this paper extend over the 6 years 1881-1886.

ANNUARIO METEOROLOGICO ITALIANO. Pubblicato per cura del Comitato Direttivo della Societa Meteorologica Italiana. Anno IV. 1889. 8vo. 304 pp.

In addition to much useful information, this contains many interesting articles,

among which may be mentioned :—Early Italian aeronautical knowledge, by Padre F. Denza (14 pp.).—The earth and the atmosphere : The prevailing winds, by C. De Giorgi (8 pp.).—Photographic measurement of the altitude and direction of clouds, by Padre G. Lais (9 pp.).—Whirlwinds in the atmosphere, by A. da Schio (10 pp.).

INSTRUCTIONS FOR MAKING METEOROLOGICAL OBSERVATIONS, PREPARED FOR USE IN CHINA; AND THE LAW OF STORMS IN THE EASTERN SEAS. By W. DOBERCK. (China. Imperial Maritime Customs. II. Special Series. No. 37.) 4to. 1887. 88 pp.

These Instructions have been issued for the information of meteorological observers in the Treaty Ports of China, which extend as far north as Newchwang, and as far west as Ichang and Pakhoi, and also for the use of commanders of vessels of all nationalities frequenting the China Seas. The work would have been more valuable if illustrations had been given of the various instruments.

INSTRUKTION FÜR DIE BEOBACHTER AN DEN METEOROLOGISCHEN STATIONEN II., III., and IV. Ordnung. 8vo. 1888. 77 pp.

These Instructions have been issued for the use of the observers in connection with the Royal Prussian Meteorological Institute, and have been prepared by Dr. Hellmann, Dr. Sprung, Dr. Assmann, and Dr. Kremser. The work is illustrated by 29 cuts, showing the various instruments and how to read them.

MEMORIE DELLA R. ACCADEMIA DI SCIENZE, LETTERE ED ARTI DI MODENA. Vol. VI. Serie II. 4to.

Contains a paper by Prof. D. Ragona, entitled "Vero andamento diurno della temperatura" (27 pp.).

METEOROLOGISCHE ZEITSCHRIFT. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. HANN und Dr. W. KÖPPEN. October-December 1888. 4to.

The chief articles are :—Klima das Ben Nevis in NW Schottland, von A. Woeikof (9 pp.). This is a summary of the various papers on the results from Ben Nevis which have been published by Mr. Buchan and Mr. Omond.—Ueber das Gesetz der Absorption der Sonnenwärme in der Atmosphäre, vom O. Frölich (9 pp. and plate).—Bewegung der Cyklonen und Anticyklonen im November 1884 in der Umgebung des Nordatlantischen Oceans (4 pp. and plate). This is a reproduction of two of the charts of the weather over the Atlantic which appear regularly in the *Viertel-Jahrs-Welter-Rundschau* of the Deutsche Seewarte.—Gewitterelektricität und gewöhnliche Luftelektricität, von L. Sohncke (13 pp.).—Beobachtungs-Ergebnisse der norwegischen Polarstation Bossekop-Alten (6 pp.).—Ueber die Abrundungs-Fehler meteorologischer Zahlen, von J. Kleiber (9 pp.).—Die Bestimmung der Durchschnittstemperatur durch das Gewicht von verdampfter Flüssigkeit, von W. Müller-Erzbach (7 pp.). This is a new method for determining the average temperature of the air for a definite interval of time by the amount of water evaporated during that interval. The water is contained in a glass tube blown into a bulb at one end, and the whole is suspended inside a large closed vessel, partly filled with sulphuric acid, to absorb the vapour. The determination is made by the loss in weight of the glass tube. The author claims considerable accuracy for the process.—Ueber die vertikale Abnahme des Luftdruckes und der Temperatur, von A. Sprung (10 pp.). This is an investigation of the question whether the vertical decrease of temperature in the atmosphere takes place in geometrical progression, as maintained by some physicists, or in an arithmetical progression as Hann showed in 1874. Dr. Sprung investigates the way in which the first-named mistake has arisen.—Ueber die Gestalt der Isobaren in ihrer Abhängigkeit von Seehöhe und Temperatur-Vertheilung, von W. Köppen (11 pp.). This is an endeavour to construct isobars at a high level from the known rates of decrease of pressure with height under different conditions of temperature. In front of a depression the temperature is high and in the rear low, the distribution of pressure at a level of say 2,500 metres is therefore con-

siderably modified in accordance with definite principles. Dr. Köppen hopes at a future time to produce charts of high level isobars for the whole globe.

PROGRAMM DES K.K. OBER-GYMNASIUMS ZU KREMSMÜNSTER. 1888. 8vo.

Contains a paper by Prof. C. Wagner entitled "Niederschläge und Gewitter zu Kremsmünster" (32 pp.). This gives the monthly and annual rainfall for the 67 years 1821-87, and the number of days of thunderstorms in each month for the 86 years, 1802-87.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. Vol. XXIII. Nos. 274-276. November 1888-January 1889. 8vo.

The principal articles are :—An improvement in anemometers, by H. C. Russell, F.R.S. (1 p.).—Great rain at Geneva, October 2nd-3rd, 1888 (3 pp.).—Lightning and its effects, by R. J. Lecky (2 pp.).—Mr. Abercromby's Travels (2 pp.).

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EDITED BY A

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Royal Meteorological Society.

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SESSION 1889.

ORDINARY MEETINGS at 7 p.m.

Wednesday,	February	20, 1889.
,,	March	20, ,,
,,	April	17, ,,
,,	May	15, ,,
,,	June	19, ,,
,,	November	20, ,,
,,	December	18, ,,

ANNUAL GENERAL MEETING.

Wednesday, January ..... 15, 1890.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

NOTICE.

The Library and Offices of the Society are open daily from 10 a.m. to 5 p.m.; Saturdays, 10 a.m. to 2 p.m.

The Society is not responsible for the views and opinions advanced in the *Quarterly Journal*.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XV. APRIL 1889. No. 70.

ON FOGS.

An Address delivered at the Annual General Meeting of the Royal Meteorological Society, on January 16th, 1889.

BY WILLIAM MARCET, M.D., F.R.S., PRESIDENT.

ONE day in July 1878, I stood on the Peak of Tenerife, 5,500 feet above sea-level, having just emerged from the thick damp fog which surrounds its base, like a belt in mid-air. A few minutes before, the well-defined red disc of the sun had announced the near approach of the upper level of the fog; then the solar heat began to tell, and presently I found myself in a clear atmosphere upon the very brink of a sea of clouds. The view was remarkable indeed,— a light breeze lifted and carried away the delicate tangled wreaths of condensed moisture—here encircling each other; there racing in a straight course; now curling over and over, and soon vanishing into thin air. What surprised me most was the unchanged appearance of the fog-level—while speedily absorbed into the dry air of the higher atmosphere, still the level of the fog continued exactly the same; hence the fog was being renewed from the sea below precisely at the same speed as it disappeared in the air above. How are we to account for this fog-stratum, 2,800 feet in thickness,

constantly forming and dissolving, though unchanged in its appearance? The temperature of the sea in the 28th degree of north latitude, that of Tenerife, is what we should call very high, ranging between 75° and 80°, consequently the evaporation from the surface of the Atlantic near that island is considerable. Damp air being lighter than dry air, a mass of lighter air ascends from the surface of the sea, which presently meets with the cool, damp, North-east Trade Wind, and at a height of about 8,000 feet the vapour from the sea condenses into fog. This fog is white, very dense, and very damp, and throughout its extent in depth the NE Trade is felt as a light breeze.

I spent three weeks on the Peak above the fog, in a climate so hot that the sand felt too warm to allow of the prolonged contact of the hand with it, and the dryness of the air was such that the leather of our boots cracked and opened, the deal boxes of instruments split asunder, and the skin of our hands became white and scaly. The stock of meat we had taken with us showed no sign of decomposition in the dry air of the Peak,[1] but was attacked by a swarm of flies, which most provokingly delighted in laying their eggs in it.

On returning to the sea-side, when our stay on the Peak of Tenerife had come to an end, it was with an indescribable feeling of relief and comfort we entered the fog-stratum, and filled our lungs with air charged with particles of moisture.

The essential conditions for the formation of a fog are illustrated on the Island and Peak of Tenerife; these are relatively warm water and a cooler atmosphere.

The law applies to every source of vapour, whether this be sea, lake, river or damp soil.

Sea fogs—frequent in autumn and spring—are owing, in autumn, to the water not having yet parted with its summer heat, and to the accession of cold air from the autumn season, which condenses the evaporated water from the sea. Spring sea fogs are due to damp, warm air, coming in contact with the sea, which still retains its winter cold. The most permanent and extensive sea fogs are probably those met with on the Banks of Newfoundland. They occur at all seasons of the year, but are most frequent during the months of June and July. With Easterly winds they almost constantly prevail, with Westerly winds they are less frequent and of shorter duration.

Their formation is clearly due to evaporation from the warm water of the Gulf Stream in Mid-Atlantic, while there is a wide current of cold water flowing from the north along the Newfoundland Coast, so that when Easterly winds prevail, the vapour from the Gulf Stream is wafted over the cold stream of water driving down from the north along the coast, and is con-

[1] The remarkable property dry air possesses of preserving animal food was shown in a remarkable degree when, some years before my trip to Tenerife, I was out buffalo hunting on the American prairies of the State of Nebraska. We had an abundance of buffalo meat hanging in strips to our tents and the saddles of our horses; no decomposition whatever occurred in the meat, and it slowly dried up, ever ready to be used as an article of food.

densed into fog. Mr. Scott, in his excellent treatise on *Elementary Meteorology*, remarks with reference to Newfoundland fogs, "that they are often as sharply defined in extent as the hardest looking wool-pack clouds; and it is not an uncommon phenomenon when a fog bank is lying off the Harbour of St. John for the bowsprit of a ship to be seen emerging from a fog while not a trace of the masts or hull is perceptible, and again at times the topmasts will be in bright sunshine while the crew cannot see from stem to stern on deck."

Dense Atlantic fogs are not, however, limited to the banks of Newfoundland; indeed, the most frequent locality of thickest fogs may, perhaps, be found on the northern side of the Gulf Stream.

All over the Western Atlantic fogs only occur when the winds blow off the Gulf Stream, that is from the southward; when the wind goes to the North of West, they clear off at once. For these last particulars I am indebted to the kindness of Captain Wharton, Hydrographer to the Admiralty.[1]

Obviously fogs are checked by a state of excessive dryness of the air, and do not form if the weather continues warm and dry late in the season; thus it is that in such places as the Riviera, where the autumn and winter temperatures are high and the atmosphere dry, there is a conspicuous absence of fogs. A similar remarkable freedom from fogs is observed at some mountain stations, such as Davos, the well-known winter sanatorium, in Switzerland, where the atmosphere is very cold and dry, and is not liable to admixture with damp air.

Lake fogs.—The neighbourhood of lakes and marshes is very favourable to the production of fogs, especially places at some height above them, and in a relatively cold temperature. Thus the Ben Nevis Observatory, at an altitude of 4,406 feet, has the full benefit of the vapour arising from Loch Linnhe and Loch Eil, and the three solitary inhabitants of this lofty post of observation have seldom a clear day. The daily weather article in the *Times* reports the air at that station as generally saturated, which means that it either rains, or snows there, or that the station is in a fog.

It is a common occurrence upon the summit of the Righi mountain in Switzerland to meet with dense white fogs ascending from the lakes of Lucerne or Zug; and again, visitors to the Great St. Bernard Pass well know how often the long-wished-for view of the Convent or Hospice is cut off by a thick fog. In this case the vapour does not take its origin from any neighbouring lake, but is carried towards the Alps from the Mediterranean Sea by the South and South-west winds.

River fogs are of frequent occurrence, and in the cold damp air of early morning the windings of a stream may be seen from above clearly mapped out by a well-defined line of fog. While ascending the Nile, on board a dahabeeyah, in the winter of 1885, I had opportunities of observing the fog which often forms about sunrise on that mighty river. On February 5th, having left Cairo the previous evening, there was a fog at sunrise over

[1] *Newfoundland and Labrador Pilot.* Second Edition.

the river which lifted about 8 a.m. The temperature of the water of the Nile was then 58°·8, and the minimum temperature of the air the night before, corresponding nearly to the time the fog was observed, was 45°·8—a difference, therefore, of 18° in temperature between the water and the air, fully accounting for the condensation of vapour. February 6th was again foggy in the early morning. On February 24th a fog rose from the South at 6 p.m., while to the North the air was perfectly clear; indeed, fogs are frequent on the Nile up to about the latitude of Kenneh, say 26°37′ N. But the most interesting river fog I ever witnessed was on the Thames on October 27th last, when I happened to be spending the day at Greenhithe. There was no fog in the morning on the high ground above the river, and the air was absolutely still; but the Thames was covered along its many windings with the thickest white fog imaginable; so much so that boats moored close to the bank could not be seen. The masses of condensed vapour rose, however, to no great height, as the tops of the tallest masts just appeared now and then. From the invisible track of the river there issued such a diversity of sounds as to baffle every description. The loud, clear notes of the steam fog horns, the tolling of many bells, and the unearthly drumming of a huge gong on board an absolutely invisible dredger close by, all united in strains most novel, though certainly not harmonious. Then suddenly, as if by magic, the fog disappeared; it did not lift nor was it blown away, but it simply vanished in a light Easterly breeze. Stillness now prevailed, though the bustle on the river was at its height; large steamers on their way to the sea, barges, yachts, were all on the move, and how they had steered clear of each other in the fog (if under way before it lifted, as they seemed to be) was quite unaccountable.

There is a form of fog called by Herschel *radiation fog*, which forms when, on a clear evening, the ground parts rapidly with its heat by radiation, causing a marked fall of temperature. If the soil be damp or marshy the air becomes saturated near the earth's surface, and the cold increasing, a low fog appears, rising but a few feet above the ground. This is of common occurrence in flat and low districts.

Waterfall or Spray Cloud.—You must now allow me to allude to the very peculiar and I believe constant cloud which forms over great waterfalls. At a considerable distance from the Falls of Niagara, and long before the mighty roar can be heard, a mass of cumulus cloud is visible hovering over the Falls. The height of the Falls on the American side is about 164 feet, and on the Canadian side 150 feet; the waters plunge into an abyss 1,000 feet wide, and the spray rises to a great height, but there is a clear space between the spray and the cloud.

The Victoria Falls of the Zambesi, discovered by Livingstone, must, I conclude, exhibit a cloud similar to that over Niagara. It will be seen that Livingstone in the following account infers the existence of the cloud without having distinctly observed it. "About 20 minutes' sail from Kalai we came in sight for the first time of the columns of vapour appropriately called 'smoke,' rising at a distance of five or six miles, looking exactly as when

large tracks of grass are burnt in Africa. Five columns now rose, and bending in the direction of the wind, they seemed placed against a low ridge covered with trees; the tops of the columns in this distance appeared to mingle with the clouds, they were white below, and higher up became dark, so as to simulate smoke very closely. The Falls are known by the name 'Mosi-oa-Tunya,' which means "smoke sounds there," from the admixture of the noise and spray."

The Victoria Falls are formed by a stupendous crack or rent with sharp and almost unbroken edges, stretching right across the river. The cliff is 360 feet in sheer depth, and close upon a mile in length. Into this chasm of more than twice the height of Niagara the river rolls with a deafening roar, sending up vast columns of spray, which are visible from a distance of twenty miles.

Town Fogs.—In general, the less said about an unpleasant companion we have to put up with, the better; we cannot honestly speak well of him. So it is of town fogs. In the Polar regions, where sunlight is impossible for months throughout the winter, the bright Auroræ shine pleasantly; but in our towns we have no substitute for Auroræ but gas-lights, and these are actually invisible in our dense black fogs. The absorbing power of such fogs for light is a physical phenomenon none the less remarkable because it is common; no night, ever so dark, can compare with the shades of one of our intense London fogs. Such fogs often accompany a rising barometer, and are frequently dry in their character. I mean that although, as a rule, air is saturated with moisture in a fog, it is often not so in particular instances. Prof. Frankland, F.R.S.,[1] made some very interesting experiments on the influence of coal-smoke on foggy air, and found that water, when its surface is covered with a film of coal-tar, evaporates much less readily on that account. The results of these experiments explain the production of dry fogs. In a Lecture at the Royal Institution the same author remarks that the fog once formed is rendered more consistent by the coating of tarry matter which the fog particles receive from the products of the imperfect combustion of smoky coals.

December is the usual time of the yearly occurrence of our town-fogs, clearly because of the summer heat retained by the soil, coupled with the accession of cold of the autumn season; and it is obvious that heavy rains in November will promote this phenomenon in no small degree. People in London have their own grievances against London fogs, while our friends abroad fancy that London is buried in a dense fog most of the year. I may, perhaps, be allowed on the present occasion to recall a rather curious personal experience. Some years ago, about 8.30 p.m. one afternoon in December or beginning of January, in one of the densest fogs, I walked with my son along the south side of the Serpentine from the bridge to Hyde Park Corner. There was a thin coating of ice on the water, and as we could not see the ice we had to keep touch with it by means of our walking sticks to prevent

[1] On Dry Fogs, by E. Frankland, D.C.L., F.R.S.. *Proceedings, Roy. Soc.* 1878.

getting lost. Every now and then we were conscious of being near a tree and overhanging branches, or we thought so, but on hitting at the objects with our sticks we touched nothing solid; trunks of trees and branches were distinctly seen both by myself and my son; we pointed to the objects and described them, so that there could be no doubt we saw, or thought we saw, the same trees and the same branches, yet there were no trees and no branches when we struck at the simulated objects, or felt for them with our hands. This phenomenon, confirmed by two independent observers, is, I think, worth recording. A friend told me he was once deceived, precisely in the same way, in a fog, and some of my hearers may have made a similar observation.

I am sure you will be interested to know the main cause of our London fogs. It is a well-known fact in meteorology that cold air on the top of hills being heavier than the warmer air below, slides down the slopes so that the lower parts of hill sides are actually colder than the plains at some distance from the hills. Now London, lying in the Thames valley, is surrounded by hills—to the North, Highgate, Hampstead and Harrow; in a Westerly direction, Putney and Wimbledon; and in a more Southerly direction, Clapham and Sydenham. The air is colder on these hills than in London with its millions of inhabitants, its coal fires and factories, hence it is heavier and will have a great tendency to slide down towards the town and the river. Should the air in town be on the point of saturation, and the cold air from above saturated with vapour, it is obvious that the increased cold from above will produce a precipitation of moisture, and it will come to pass that a fog is produced. If the hill-tops be not only colder than the air below but enveloped in a fog, it stands to reason that the fog below will be all the denser, and especially in the neighbourhood of water, such as the river Thames, and the ornamental waters in the Parks.

The following is a case in point. On December 31st last London was visited by one of the densest fogs I have experienced. On walking to the Putney Railway Station from Wimbledon Park at half-past ten o'clock in the morning, I met with a clear white fog. It apparently reached to no great height, and interfered but moderately with light, as I could read the *Times* newspaper quite easily in the train, through tinted glasses. On Wimbledon Common the mud and puddles were frozen, and the temperature must have been somewhat below 32° Fahr. Reaching town a few minutes after eleven o'clock, I found the streets comparatively warm, with no signs of frozen mud, but the fog had considerably increased and was becoming yellow. Towards the middle of the day it subsided, and in some parts disappeared, but shortly after six p.m. it returned with increased intensity, and then was witnessed one of those atmospheric phenomena calculated to rank as a positive calamity; darkness reigning supreme, traffic suspended, and people groping their way through the streets as if they had lost their sense of sight. As I was walking to Victoria Station, on my way home, between 7 and 8 p.m., the temperature appeared to me to be remarkably mild, and there was no sign of frost anywhere. At Putney I felt quite chilly, while on Wimbledon Common I found

the mud frozen hard and the puddles covered with ice. On reaching home in Wimbledon Park, I at once examined my thermometers in a Stevenson screen; the temperature observed was 24°·5, or 7°·5 below the freezing point. The fog had not yet lifted, and was indeed very thick. The weight of a cubic foot of air at a temperature of 24°·5 is 555·5 grains, while at 40°—the approximate temperature of the London streets on that evening—a cubic foot of air weighs 587·5 grains, giving an excess of weight of 18 grains for the air on Wimbledon Common; hence the cold foggy atmosphere on the Common, being heavier by 18 grains per cubic foot than the warm air in the London streets, slid downwards towards the Thames valley, contributing towards the dense fog in town. This same state of the atmosphere occurred all round London.

There are certain atmospheric phenomena resembling fogs, although of an entirely different nature. The air invariably holds dust in suspension, and, as shown by Dr. Tyndall, it is to this dust that we are indebted for the perception of light. When a ray from the sun or electric lamp is projected into a dark room through air or water from which this dust has been removed, there is seen a break in the ray of light, and the space free from dust appears dark. Under certain peculiar conditions it so happens that this dust, though usually invisible, imparts to the air a hazy appearance. At all events, it is impossible to explain otherwise the peculiar haze which accompanies the North-east gales in the Geneva valley in Switzerland. On looking Northwards over the lake, towns and promontories about ten miles distant may disappear completely from sight; while other points three or four miles off are enveloped in a thick mist. Yet the sky is cloudless, and the air is dry; indeed, the North-east or North-north-east wind, called "the bise," is peculiarly dry. This haziness of the atmosphere attending the "bise" is so constant that persons in the habit of yachting and boating on the lake are able to judge from the intensity of the mist whether the wind is likely to increase or subside. If the haze increases, objects in the distance becoming less visible, the gale is pretty sure to continue; while a clearing up of the atmosphere is a sign that the wind is not likely to last. This atmospheric phenomenon has been described by Dr. Henry Bennet, of Mentone, in the local paper of Evian, the well-known bathing resort on the French coast of the Lake of Geneva.

There is also, or to speak more to the point, there must be, a condition in the atmosphere approaching to a mist, wet or dry, if we wish to account for certain remarkable shadows occasionally seen in the mountains. This is certainly one of the most extraordinary and ghostly of the natural phenomena of the atmosphere. From my camp at Alta Vista, on the Peak of Tenerife, at an altitude of 10,700 feet, I used to see, just before sunset, the shadow of the Peak cast by the setting sun; it floated in the atmosphere on a sea of clouds, some portion of it hovering, perhaps, over the island of Grand Canary. The terminal cone was invisible from my station, which faced the East, but the mighty and imposing shadow of the Peak, with its summit clearly defined, was clearly projected eastwards, at a few miles distance. The shape of the

shadow was very like an elevation view of the Peak, but there were peculiar dark smoke-like rays issuing from the culminating point, which could not possibly be accounted for. Others have observed this same shadow, and Mr. Abercromby alludes to it in the interesting narrative of his meteorological observations on the Peak of Tenerife, which he communicated to the Society some short time ago.

But this is not a solitary instance in my experience of ghost-like shadows forming on some invisible material. A similar phenomenon occurred one night in August 1887 in the valley of Zermatt. I was in the drawing-room at the Hotel de Zermatt, about 10 p.m., when, looking out of the window towards the Matterhorn, I was surprised to see the image of that magnificent rocky pinnacle thrown on the left-hand side at a small distance from it. There was absolutely nothing to be seen behind this shadow on which it could have been cast; the sky was clear and the stars shone brightly, while the edges of the Matterhorn itself were fringed with the bright light of the moon, which was rising behind it. Was this a shadow owing to the rising moon, as it appeared to be; or was it a phenomenon of mirage, owing to differences of temperature in the atmosphere? I cannot tell, but, oddly enough, there were the same dark smoke-like rays I had seen at Tenerife, floating like a pennant from the summit of the shadow. I called the attention of a distinguished painter, who happened to be in the room, to this remarkable phenomenon. He had never seen it before, and was much struck by it.

Fogs and clouds are one and the same thing. A cloud when entered into is found to be a fog, and a fog seen from a distance, suspended in the air, becomes a cloud. It may occur to my hearers to ask a question I have often put to myself, viz. What gives the clouds their definite shape? Why are some of them we call 'cumulus,' rounded, fleecy, and woolly in their character; while others, known as 'stratus,' are long, flat, and heavy? And, again, Why do some clouds, distinguished by the name of 'cirrus,' assume a light, delicate, lace-like appearance? These are questions very difficult to answer.

I have a vivid recollection of a certain day on the Peak of Tenerife, while lying on the sand under a wooden shed I had erected, like a huge parasol, as a screen against the dazzling sun, when suddenly I became aware of a minute, white, round cloud floating in the dark-blue atmosphere at a considerable height, and looking like a balloon or a ball of cotton wool. For a fortnight I had not seen the vestige of a cloud, and the air continued persistently dry. The little cloud I was looking at was absolutely alone in the sky, quite motionless, and there it remained for a few minutes, neither getting larger nor altering in shape. Then it began to fade, and in a twinkling had disappeared. What had given rise to this cloud? How could an accession of vapour have occurred at that very spot in the atmosphere; or could there have been a fall of temperature thus localised in mid-air? The book of nature, opened to all, affords a study delightful though difficult, and many of its pages are written in an unknown language. It is our duty, however, and a pleasant one, to read that book and try to understand it, rejoicing over ever so little it may be in our power to master. There was a meaning in that

small cloud I had seen high up in the air, from the Peak of Tenerife; the humidity of the atmosphere was increasing, and this accession of moisture appeared to come from above. The next day I shifted my camp, and rose from 7,000 feet to 10,700 feet. At this second station the air was much less dry, which was clearly shown by hygrometer observations; and also from the fact that my stock of fresh meat, which, so far, had resisted decomposition, commenced to decay. Finally clouds formed low in the sky.

The shape of clouds must, of course, be due to definite laws of nature. The Alpine climber, having turned out in early morning, anxious to investigate the state of the weather, may see heavy masses of clouds in the valley below him, rising slowly and straight up. By degrees they expand and look thinner and lighter; then they seem to hug the crest of the mountains in round fleecy masses, and soon disappear. This form of cloud is owing to a fall of temperature produced by radiation in the damp valley, and to the heavier cold air from the mountain summits sliding down the slope into the hollow. The mist disappears in the drier air as it ascends; and this is, of course, a sign of fine weather. At times long dense clouds are visible; their form, I apprehend, is owing mainly to the action of the wind, coupled with certain conditions of atmospheric humidity, and it will be found that generally the long axis of such "stratus" clouds moves transversely to the direction of the wind. The clouds called "cirrus," forming at altitudes of about 16,000 feet and higher, and remarkable for their delicate texture, are supposed to be composed of masses of small crystals of frozen moisture. In rain-clouds, or "nimbi," there must be a great cohesion in the particles of vapour, due to an accession of cold.

Mr. Glaisher, in his book on balloon ascents, has given beautiful illustrations of clouds seen from above, but such views may be had from any elevated spot, such as a mountain summit or a high hill. The upper surface of a fog is admirably defined. It has the appearance of a white sea with huge billows rolling over it, but the waves are still, and their spray is caught up in mid-air. The eye wanders far and wide, and yet there may be no break in the sea of clouds. No objects appear in this vast and silent ocean, but stay—an immense mass of snow floats yonder in the distance; you expect to see it tossing about on the disturbed waters, but no—there it rests motionless, unchanged. Further does the eye reach, and the waves look smaller and smaller in the distance; but lo! the scene is changed,—there, as far as the sight can carry, the water is smooth, the setting sun is reflected upon it, and glows in such a peculiar way as to make the picture resemble a vast ice-floe of the Polar regions. By degrees a pink haze extends over the ice, merging higher and higher in the sky into yellow, green and blue. Simulated snow hillocks in various directions now take up those beautiful shades of red and pink peculiar to mountain scenery above the snow-line; but the sun is near setting, and the lovely colours dissolve into a most delicate mauve; the shades of evening now envelop this enchanting but ghostly scene, and nothing is left of it but a bright pink line extending all over the visible horizon. This lasts but a minute or two, and then fades away into darkness.

Sometimes lower hills, or trees, peep out of this sea of fog, looking exactly like so many islands, and it may also happen that the fog abutting against a mountain-side or hill-slope, will give a picture of the sea with its silent waves breaking on the shore. Again, a rent may appear on the smooth cloud-surface, into which the mist is precipitated like a foaming torrent.

Such views of fog-levels are not uncommon in the mountains, but nowhere have I seen them so perfect as from the Peak of Tenerife, where they were repeated every day with varied forms and varied colours.

The physical properties of fogs now claim our attention, and I cannot help giving a passing notice to the beautiful and graceful deposits of frozen mist in a cold winter day on all objects out-of-doors, especially trees and grass. As the fog continues in the frosty air, so does the mass of sparkling crystals increase in thickness round every bough and twig until the dark stick has nearly disappeared under a spotless coating of hoarfrost; and the leaves of hollies and rhododendron bushes become fringed with lovely wreaths of long needle-like crystals.

An interesting property of fog, too often overlooked, is the power it possesses of checking the loss of heat from the soil by radiation. On a fine clear evening at sunset a well-known sensation of chill is often experienced, and the ground undergoes a rapid loss of heat. In countries where the air is particularly dry and clear, such as the coasts of the Mediterranean Sea, Cairo in Egypt, and many places in Italy, the cold experienced at sunset, owing to the earth parting with its heat, is acutely felt. On the Peak of Tenerife, above the fog-level, although in the middle of the month of August, with a suffocating heat in the daytime, I was unpleasantly conscious of cold at night; and any water left outside the tent overnight was found frozen into a solid mass of ice by the following morning. An increase of atmospheric moisture acted as an immediate check to this loss of heat, and when towards the end of my stay on the Peak the air became damper, the nights were much less cold. Now, when atmospheric humidity forms into clouds, and especially when the sky is overcast, the earth loses its heat in the evening much less rapidly than it does under a clear sky; in fact, the chilly sensation experienced after sunset is hardly noticed at all. A fog also checks terrestrial radiation, although often, if not usually, productive of a sensation of cold. This chilly feeling is owing to two different causes:—first, the accession of cold to which the fog owes its formation; and second, the fact that a fog or a cloud being a better conductor of heat than dry air, we feel cold in a fog, just as touching a marble slab or a piece of iron conveys a perception of cold. Still, a fog undoubtedly protects the earth from loss of heat. Autumn or winter fogs thus exert a most beneficial effect, being productive of a slow transition from autumn to winter, which makes up to a considerable extent for the well-known deleterious effect of fogs on health, and is a boon to vegetation.

Besides checking the emission of terrestrial heat into space, it has been shown by Dr. Russell that London fogs arrest, in a great measure, the diffusion of carbonic acid through the atmosphere, or in other words, they cause

accumulations of this noxious gas in our streets and in our houses, and no amount of ventilation can get rid of it. During a dense fog Dr. Russell found in the air just outside St. Bartholomew's Hospital more than three times the ordinary proportion of carbonic acid present in clear weather, and amounting to an extreme of 14 parts instead of 4 in 10,000. I obtained a somewhat corresponding result in the grounds of University College. On November 3rd last, the fog having just cleared off, the proportion was 4·63 parts in 10,000, that is slightly over the average; but on December 11th last in a dense yellow fog it amounted to 10·4 parts in 10,000. Now carbonic acid is a normal constituent of the atmosphere, though varying in its proportion. While experimenting conjointly with Dr. Landriset, of Geneva, we found that when the air was quite clear under a blue sky the proportion of carbonic acid was the same near Geneva and on the summit of the Dôle, the highest point of the Jura chain, the difference of level between the two stations amounting to very nearly 4,200 feet. The analyses of air were made at the same time at both places, so that the results are strictly comparable with each other. When the observer on the Dôle found himself in a fog, which happened on several occasions, the proportion of carbonic acid in the air fell below that contained in the air of the valley. Now there is this difference between a London fog and a fog or a cloud on a mountain summit—that in the case of the town fog carbonic acid gas is abundantly formed in the fog itself, mainly from coal fires; while clouds on mountain tops are at a distance from the source of the gas, and it has to come up from below and enter them. The outer layers of a cloud would absorb the carbonic acid of the air surrounding it, and leave but a relatively small amount to reach an observer inside the cloud. This explanation, though somewhat insufficient, is so far the only one which has been suggested.

A very remarkable physical property of fogs is their power of transmitting sounds. They were thought to exert an opposite effect until Dr. Tyndall took up the subject in 1874, and finally communicated his results in a very interesting paper to the Royal Society. He began by experimenting, on a small scale, over the Serpentine in Hyde Park, with three organ pipes of different lengths, a dog whistle, a small bell, and some percussion caps. In a dense fog, on December 10th, 1874, the sounds from these objects were well heard from one side of the Serpentine to the other, and Dr. Tyndall could converse easily with his assistant across the water. Two policemen informed the Professor that they had heard the bell of Westminster that day with great distinctness; the same sound had reached them still more distinctly on another night through an exceedingly dense fog, while on many clear days they had failed to hear it at all. On the day the experiments were made across the Serpentine, the clangour at twelve o'clock was very loud.

There appeared to the Professor to be an extraordinary amount of sound in the air in the dense fog on December 10th. He perceived a resonant roar from Bayswater to Knightsbridge; the railway whistles were extremely distinct, while the fog signals exploding at the various metropolitan railway stations kept up a loud and almost constant cannonade.

Dr. Tyndall quotes Sir Frederick Abel's remarkable experience on the propagation of sound in fogs from the firing of guns at Woolwich. In a dense fog, Sir F. Abel from his house, and his office about three-quarters of a mile from the butts, experienced the concussion from the practice with 64 pounders and 10 lb. charges decidedly more distinctly than that produced by the firing of the heaviest guns, with charges of from 110 to 120 lbs. of powder, in ordinary weather.

I might continue adding to the foregoing statements, but they suffice to show that sound is propagated much more readily through fogs than it is in a clear atmosphere. This is indeed a most fortunate circumstance, allowing of fog signals at sea to be heard at a great distance, the sounds of a horn or a siren reaching ships ten miles off.

The phenomenon known as the "Spectre of the Brocken," because frequently observed in that part of the Härtz Mountains, may also be seen elsewhere. It consists of shadows projected by the rising or setting sun upon banks of fog; these shadows are immensely enlarged images, and have a very spectral and ghostly aspect; they are often surrounded by one or more rings, exhibiting the colours of the rainbow, and called fog-bows or "glories." A very interesting paper on Brocken Spectres was communicated to the Society in 1887 by Mr. Henry Sharpe. He quotes Dr. Tyndall's experience on the subject from the Professor's book on *The Glaciers of the Alps*, as follows:—"The sun was sloping to the West . . . . As the sun sank, the shadow of the Finster-Aar-Horn was cast through the adjacent atmosphere. Proceeding along the mountain to the Furca, we found the valley at the farther side of the pass also filled with fog, which rose like a wall high above the region of actual shadow. Once, on turning a corner, an exclamation of surprise burst simultaneously from my companion (Prof. Huxley) and myself; before each of us and against the wall of fog stood a spectral image of a man of colossal dimensions, dark as a whole, but bounded by a coloured outline. We streched forth our arms, the spectre did the same. We raised our alpenstocks, the spectres flourished their batons. All our actions were imitated by the fringed and gigantic shades. We had, in fact, the 'Spirit of the Brocken' before us in perfection."

Fog-bows are thus described by Dr. Frederick Taylor[1]:—"While staying at the Bel Alp Mr. Gotch and I ascended the Grisighorn on August 13th, and were on the summit about four o'clock in the afternoon. As we sat under the shelter of the cairn, facing toward the Sparrenhorn, the sun was at our backs, and from time to time clouds rolled up before us from the rock beneath. Suddenly we saw the shadow of the summit of the mountain and of ourselves thrown on the cloud, and at the same time a rainbow, with the colours fully developed, became apparent. As we sat the rainbow was already more than the usual semicircle, and on mounting on the cairn I saw a complete circle of colours, with the red external and the violet internal. Of

[1] *Alpine Journal*, Vol. XII.

this circular rainbow my head was the centre, and my feet touched the lower limb. Mr. Gotch also saw a secondary bow. The phenomenon remained some time, varying in the brightness of the colours and the intensity of the shadow."

As a rule each person sees his own shadow only in a fog, although other people may be near him. There are, however, exceptions to this rule. Mr. W. A. Brown, writing from Dundee in 1887, makes the following remarks: —"Another point that I remember is that when two of us came near each other, our discs (of light) cut in upon one another; and that the whole thing became visible to both of us." Again, Mr. Maynard, walking up the Piz Languard, in the Canton Grisons of Switzerland, states (in *Nature*):—"On the summit of the Peak is a ledge of rocks, on which I lay down for twenty minutes sleep. I had been asleep but a few minutes when Colani (the guide) woke me, and with excuses and an expression of fright in his face, begged me to come with him to see something which he had never seen in his life before. We moved to the Western edge of the Peak. Below us were some thin clouds of mist curling about like vapour from a large cauldron. On these clouds appeared a circular rainbow, and within it, as though in a gilded frame, were two figures—in fact the shadows of ourselves. 'There are two of them now,' cried Colani; and it was not until I told him to take off his hat and wave it as I did mine, and he saw the action repeated by the figures, that he began to feel assured that they were not 'Geister'" (spirits).

I have myself witnessed this spectral phenomenon very plainly on the Righi Kulm, where masses of clouds or fog rising abruptly from the lake of Zug follow the precipitous sides of the mountain, and reaching the summit, continue their ascending progress without extending laterally. It follows that anybody standing on the Kulm may see a pillar or a wall of fog moving upwards, while he is in a perfectly clear atmosphere. A few years ago, under similar conditions, I was standing with a friend on the brink of the precipitous cliffs of the Righi Kulm, facing the Zuger See, and I saw the shadow of my own body projected on the fog in a most mysterious way. It was at about 10 o'clock a.m., and the sun, in a South-easterly position, cast our shadows on the North-westerly bank of fog. We were both in a spot absolutely free from mist. Our two shadows were not altogether distinct; the head, trunk, and legs were obvious enough and enlarged, though I could hardly give an idea of the size; but the most remarkable feature of the phenomenon was a double concentric ring round the shadows of our heads, each ring exhibiting the colours of the rainbow. On moving our legs or arms, the giants in the fog did the same; indeed, the novelty of the occurrence was very striking, and interested us extremely.

Lunar rainbows are seen when the observer is standing in a clear atmosphere between the rising or setting moon and a bank of fog. I recollect meeting with this phenomenon at Cannes on the occasion of a mass of nimbus clouds coming up from the East, which is invariably the wet quarter. Herschel, in his book on *Meteorology*, remarks that such rainbows are common in the Weald of Kent, a district abounding in grassy slopes, and winding and

branching valleys. The bottom of these valleys on a clear calm night disappears in a sea of clouds, and on descending a few yards into the mist, under a full moon, a lunar rainbow is frequently seen. Lunar rainbows would, of course, have the same origin as solar rainbows, and be owing to a refraction and reflection of light in and from the watery particles the fog is made of.

I shall finally beg to draw your attention to bright twilights, and the beautiful effects of clouds lighted up under certain peculiar circumstances by the setting sun.

The twilights in 1884, in consequence of the material ejected into the atmosphere by the eruption of the Krakatoa volcano, were very peculiar and beautiful. The Hon. Rollo Russell refers in the following words to the effect of these twilights on clouds, in a paper published in our *Quarterly Journal* for 1884:—"The colours on the lower and upper clouds were very peculiar, and sometimes unearthly. At one time they looked quite green all over the sky, and on several occasions a sky suffused with pink was dotted with green clouds. Frequently the green light near the horizon was only sufficient to tinge the clouds greenish for a short time; and when the green colour had disappeared below the horizon, the red which was left illuminated the under surfaces of the clouds, giving the spectacle of pink clouds, floating for an hour or more on a blue or green sky."

I have had a few copies made in colours on lantern slides from the beautiful illustrations of twilights in the Report of the Krakatoa Committee of the Royal Society, and these I shall proceed to exhibit.

To conclude. In a picture gallery there are some pictures pleasing because of their brightness and the variety of their subject. A discourse on fogs is, I am afraid, absolutely the reverse. Its uniformity is monotonous, the darkness of the subject is dismal, and its cold feeling is chilly. One single attraction is left—that fogs are a striking and interesting phenomenon of nature.

REPORT OF THE COUNCIL

FOR THE YEAR 1888.

The Council have much pleasure in presenting this Report, a large amount of work having been done during the year, and considerable progress made in the investigation of one of the most interesting and hitherto neglected branches of meteorology, viz. thunderstorms. The Council have been materially assisted by the undermentioned Committees, as well as by the members of the staff.

General Purposes Committee.—The President, Secretaries, Foreign Secretary, Treasurer, Messrs. Abercromby, Ellis, Latham, and Williams.

Editing Committee.—Messrs. Inwards, Scott, and Whipple.

Standing Referee on Papers.—Mr. Eaton.

ANNUAL EXHIBITION COMMITTEE.—The President, Secretaries, Messrs. Ellis, Preece, Scott, Strachan, and Whipple.

EXPERIMENTAL RESEARCH COMMITTEE.—The President, Secretaries, Messrs. Archibald, Benn, Eaton, Ellis, C. Harding, Russell, and Scott.

DECREASE IN WATER SUPPLY COMMITTEE.—The President, Messrs. Chatterton, Latham, and Symons; with Mr. Scott, representing the Meteorological Council.

WIND FORCE COMMITTEE.—The President, Secretaries, Messrs. Archibald, Chatterton, Dines, C. Harding, Laughton, Munro, Scott, and Toynbee; with Mr. Whipple, representing the Kew Committee.

THUNDERSTORM COMMITTEE.—The President, Secretaries, Messrs. Abercromby, Inwards, Scott, and Whipple.

PHENOLOGICAL OBSERVATIONS COMMITTEE.—The President, Secretaries, Messrs. Eaton, Latham, Mawley, and Rev. T. A. Preston.

Presidential Addresses.—Two very interesting Presidential Addresses have been delivered to the Society during the year. The first by Mr. Ellis, the late President, including a discussion of the Observations of Cloud at Greenwich during the seventy years ending 1887. This inquiry showed that two maxima and two minima occurred, the first maximum in January or February, and the second in June or July; the first minimum in April or May, and the second in September. The other Address was by Dr. Marcet, on Atmospheric Electricity, when he exhibited to the Meeting imitations of flashes of lightning by throwing on a screen the enlarged image of an electric spark. This, in conjunction with the exhibition of the photographs of lightning collected by the Society, gave great satisfaction to those who were present.

Exhibition of Instruments.—The Ninth Annual Exhibition of Instruments was held, by permission of the Council of the Institution of Civil Engineers, at 25 Great George Street, from March 20th to 23rd, and was eminently successful. The Catalogue contained 155 entries, and the exhibits were arranged in eight divisions, viz. 1, Electrometers; 2, Lightning Conductors; 3, Lightning Protectors for Telegraph Purposes; 4, Objects damaged by Lightning; 5, Alleged Thunderbolts; 6, New Instruments; 7, Photographs of Flashes of Lightning; and 8, Photographs, chiefly of Clouds and of objects struck by Lightning, and some Drawings. The collection of Photographs of Lightning Flashes, taken, not only in England, but in America and on the Continent of Europe, excited much attention at our Meeting, as well as at the Conversazioni of the Royal Society, the Royal College of Physicians, and at other scientific Associations where they were subsequently exhibited.

Photographs of Lightning Flashes.—The first Report of the Thunderstorm Committee, which was limited to a consideration of the Photographs of Lightning Flashes just referred to, was read at the June Meeting of the Society. The classification of Lightning Flashes under six typical forms has been adopted already by some writers on the subject, and appears likely to be used in future, at any rate until the matter has received further investigation. The names assigned to the different types are:—1, Stream; 2, Sinu-

ous; 3, Ramified; 4, Meandering; 5, Beaded or Chapletted; and 6, Ribbon Lightning. The description of these various types will be found on pages 226-229 (*Quarterly Journal*, Vol. XIV.), together with reproductions of some of the photographs. The Committee have a very large mass of printed and other matter ready for discussion, but the illness of Mr. Abercromby has prevented much progress being made in this direction.

Experiments with Anemometers.—The Wind Force Committee have continued their inquiry, the experiments having been made by Mr. Dines, Mr. Whipple and Mr. Munro, with anemometers on a whirling machine erected at Woodside, Hersham. The results obtained were of great importance, but as they were far from exhausting the subject, the same gentlemen have been requested to continue their investigations, and an additional grant has been made towards the expense of hiring and using the small steam engine necessary for carrying out the experiments. The Council are glad to inform the Society that the Meteorological Council have also made a grant in aid of the inquiry. The results of the first set of experiments are recorded on pp. 258-259 (*Quarterly Journal*, Vol. XIV.).

Inspection of Stations.—All the stations of the Society in the South as far West as Weymouth, and in the East as far as Lincoln, were visited this year and found to be generally in a satisfactory state, although some slight changes in the zeros of several thermometers had occurred, the particulars of which will be found in Mr. Marriott's report, Appendix II. (p. 78). As a consequence of the inspection the following memorandum for the guidance of observers has been drawn up, and will probably be found useful for other Fellows who do not contribute to the tables in the *Meteorological Record*.

To the Observers of the Royal Meteorological Society.

Please give special attention to the following.

"1. WET BULB.—The muslin and conducting thread of the wet bulb thermometer should be changed *at least* once a month,

"2. When the temperature is below 32°, the bulb should be wetted about an hour *before* the time of observation, so that a coating of ice may be formed round the bulb.

"3. Clean rain water should be used, and the receptacle kept well filled.

"4. MINIMUM.—The tops of the tubes of the minimum thermometers should be examined daily, to see whether any spirit has evaporated from the column. The spirit will be colourless.

"5. SNOW.—When snow falls, always melt and measure as rain that which is collected in the funnel. If the snow have drifted, or if the funnel cannot hold all that has fallen, obtain a section of the snow in several places where it has not drifted, by inverting the funnel and melting what is enclosed; also measure the depth of snow with a foot-rule.

"6. READINGS.—After entering the readings in the note book, look at the instruments again before setting them, to see that no mistake has been made."

In consequence of the unavoidable changes in the staff caused by the resignation of two of the computers and the engagement of fresh lads who had no previous experience of the work, the *Meteorological Record* has this year been somewhat late in appearance. The Council, however, hope that its publication in future will be more prompt.

Lincoln Thermometer Experiments.—The new arrangements for taking thermometrical observations on the Tower of Lincoln Cathedral with Sir W. Siemens's Electrical Thermometer have proved to be more satisfactory than at first; and the Council hope, before long, to be able to institute a comparison between these new observations and those formerly taken on Boston Church Tower. There was some difficulty in working the instrument at Lincoln; but with the kind assistance of the Electrical Staff of the local Postal Telegraph Office, it has been put into good working order.

Phenological Observations.—Some of the observers being irregular in forwarding their returns and specimens, the Council considered that their number might be satisfactorily reduced, and consulted the Rev. T. A. Preston on the subject. The matter received Mr. Preston's earnest consideration, and he has forwarded a list of observers and also of plants to be noted for the consideration and determination of the Council.

Meetings.—The Meetings of the Society have been held as usual in the rooms of the Institution of Civil Engineers, with kind permission of the President and Council of that Institution, and have been well attended. As many find the early hour inconvenient, a circular was sent to all the Fellows, asking if the time of meeting should be changed from 7 to 8 o'clock. To this circular 115 replies were received, 45 of which were in favour of retaining the present time, 60 in favour of a change to 8 p.m., 1 for 7.30 p.m., and 9 were neutral. The Council, therefore, do not deem it advisable to propose a change in view of a majority in its favour which is so small when the total number of Fellows (525) is considered.

Publications.—The *Quarterly Journal* has been distributed to the Fellows as usual. The contents include, in addition to the two Addresses already mentioned, and the Report of the Thunderstorm Committee, a most important and careful paper by Mr. Eaton on the Mean Temperature of the Air at Greenwich, 1811-56. The Report on the Phenological Observations for 1887, by Mr. Preston; and the paper on the Non-existence of Thunderbolts, by Mr. Symons, are also worthy of note.

The *Meteorological Record*, as previously mentioned (which may be considered as part of the *Journal*), has appeared on the same lines as before, and in a short time will afford a mine of research to any one who will take the trouble to collate its contents from the commencement. The publication of observations is at present far ahead of their discussion, so that the Council trust some one or more of the Fellows will undertake to make deductions from its voluminous contents. The sale of Publications has been fairly good this year, the total sum received having exceeded £38, against a little above £26 in 1887.

Library.—The number of books increases every year to a considerable extent, partly owing to exchanges made with other Societies, partly to presentation volumes, and to some extent by purchase. The number now is so much larger than when the last catalogue was published, that the Council have decided on making a complete catalogue at an estimated cost of about £100, and they hope to publish it in the course of this year, and to present

a copy to every Fellow. This, they trust will render the Library more useful not only to the Fellows, but also to others desirous of acquiring some knowledge of the bibliography of Meteorology.

Krakatoa Report.—The Report of the Royal Society Committee on the Krakatoa Eruption has been published under the editorship of Mr. Symons. The part of the Report referring to the optical phenomena has been most carefully compiled, as mentioned in our Report for 1886, by two of our Fellows, viz. Mr. Archibald and the Hon. Rollo Russell, and an abstract of it has been printed in our *Quarterly Journal* (Vol. XIV. pp. 301-307).

Fellows.—The changes in the number of Fellows during the year has been favourable to the Society, as there are 375 paying Fellows against 370 in 1887; 132 Life Fellows against 134, and 18 Honorary Members against 18. As many as 49 Fellows have been elected during the year, against 24 retired and 14 deceased.

Fellows.	Annual.	Life.	Honorary.	Total.
1887, December 31 ...	370	134	18	522
Since elected	+48	+1	+1	+50
Since compounded	− 1	+1	...	0
Deceased	− 9	−4	−1	−14
Retired	−24	...	...	−24
Defaulters	− 7	...	...	− 7
Lapsed	− 2	...	...	− 2
1888, December 31 ...	375	132	18	525

Deaths.—The Council have to announce with much regret the death of thirteen Fellows, including one Honorary Member, Major G. Graham. The names are:—

Rev. John Byron, M.A.	elected in the Society		Jan. 15, 1873.
John Rand Capron, F.R.A.S.	,,	,,	Feb. 15, 1882.
William Hugh Cochrane	,,	,,	Mar. 17, 1880.
William Carey Coles, M.D.	,,	,,	Jan. 15, 1879.
William Horatio Crawford, J.P.	,,	,,	Mar. 19, 1879.
Rev. Richard Ford Heath, M.A., F.R.A.S.		,,	Jan. 22, 1856.
Samuel Elliott Hoskins, M.D., F.R.S.	,,	,,	May 7, 1850.
Col. Arthur S. H. Lowe, F.R.A.S.	,,	,,	May 7, 1850.
William Macgeorge	,,	,,	Feb. 16, 1881.
John McLaren	,,	,,	May 7, 1850.
Rev. Philip Hankinson Newnham, M.A.	,,	,,	Apr. 17, 1867.
Alfred North, F.R.G.S.	,,	,,	Feb. 16, 1870.
William Roper, J.P.	,,	,,	May 18, 1881.

The Council also think it worthy of note that out of the thirteen ordinary Fellows whose loss we have to regret four had been Fellows of the Society

upwards of thirty years, and three, Dr. Hoskins, Captain Lowe, and Mr. McLaren, joined it in the year of its re-constitution, 1850. Of the Fellows who were either founders (marked *F.*) or elected in the first year we still have with us:—

Brown, Isaac, F.R.A.S.
Ebury, The Rt. Hon. Lord.
F. Glaisher, J., F.R.S.
Graham, John.
Hippisley, J., F.R.S.
F. Johnson, W., F.R.A.S.
F. Lowe, E. J., F.R.S.
Perigal, H., F.R.A.S.
Prince, C. L., F.R.A.S.
F. Slatter, Rev. J., F.R.A.S.
Tudor, E. O., F.S.A.

Finance.—The statement of receipts and payments during the year (Appendix III. p. 82) is satisfactory, as it shows a balance in hand of £342 4s. 2d. against £217 17s. 0d. on December 31st, 1887.

APPENDIX I.

LIST OF BOOKS PURCHASED.

BENT, W.—Eight Meteorological Journals of the years 1793 to 1800, kept in London; including Tables from eight preceding Journals of the years 1785 to 1792. 8vo. (1801.)

ELLIS, D.—Farther inquiries into the changes induced on atmospheric air by the germination of seeds, the vegetation of plants, and the respiration of animals. 8vo. (1811.)

ENCYCLOPÆDIA BRITANNICA.—Ninth Edition. Vols. XXIII. to XXIV. 4to. (1888.)

HANN, DR. J.—Atlas der Meteorologie. (1887.)

HOWARD, L.—The Climate of London. In two volumes. 8vo. (1818 and 1820.)

MASON, M.—Aeronautica. 8vo. (1838.)

OFFICIAL YEAR BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland, 1888. 8vo. (1888.)

INSTITUT METEOROLOGIQUE DANOIS ET LE DEUTSCHE SEEWARTE.—Cartes Synoptiques Journalières du Temps, embrassant le Nord de l'Atlantique et une partie des Continents avoisinants, June 1884 to May 1885. Folio. (1887-8.)

ROSS, CAPT. SIR J.—Narrative of a Second Voyage in search of a North-west Passage, and of a residence in the Arctic regions during the years 1829 to 1833. 4to. (1835.)

THE INTERNATIONAL SCIENTIST'S DIRECTORY. 8vo. (1888.)

"THE TIMES" REGISTER OF EVENTS in 1887. 8vo. (1888.)

TOMLINSON, C., F.R.S.—Winter in the Arctic Regions and Summer in the Antarctic Regions. 8vo. (1872.)

TOWNLEY, R.—A Journal kept in the Isle of Man. In two volumes. 8vo. (1791.)

WELLS, DR. W. C., F.R.S.—An Essay on Dew. 8vo. (1814.)

WILDE, W. R.—Narrative of a Voyage to Madeira, Teneriffe, and along the Shores of the Mediterranean. 8vo. (1814.)

WRANGELL, ADMIRAL F. VON.—Narrative of an Expedition to the Polar Sea, in the years 1820-23. Second Edition. 8vo. (1844.)

APPENDIX II.

REPORT ON THE INSPECTION OF THE STATIONS, 1888.

All the stations in the South as far West as Weymouth, and in the East as far North as Lincoln, have been visited during the past few months, and were found generally to be in a satisfactory condition. A longer interval than usual has elapsed since the previous inspection, the stations in the South having been last visited in 1884, and in the East in 1885.

Several changes in the zeros of the thermometers have occurred, mostly with the mercurial ones, which have risen slightly. The ordinary minimum thermometers in the screen, in seven or eight cases, had spirit at the top of the tube, and in some instances the spirit had most probably been there for a considerable time.

In two cases the grass minimum thermometers had as much as 9°·5 and 6°·0 respectively of spirit at the top of the tube; in the former case the station was about to undergo reorganisation, and in the latter the observer had been away for some weeks, and only returned the day before my visit.

Observers cannot be too careful in watching the top of the tubes of their minimum thermometers for the first appearance of spirit there, and also in seeing that when set the reading agrees with that of the dry bulb.

All the earth thermometers, where practicable, have been tested. In several cases the zeros of these thermometers, which are nearly all mercurial, have risen, in two instances 0°·4. As this is comparatively a new instrument it is probable that the tubes are not very old, and so the glass has a tendency to contract, and thus cause the mercury to give too high a reading.

The electrical thermometer at Lincoln has been examined and overhauled by the Postal Telegraph officials, and is now working very satisfactorily. At the time of my visit the reading was within 0°·2 of that of the check thermometer.

WILLIAM MARRIOTT.

October 17th, 1888.

NOTES ON THE STATIONS.

ADDISCOMBE, *October 11th.*—This station was in good order.

ASPLEY GUISE, *August 30th.*—The trees and shrubs on the South-west to the North-west of the instruments have grown considerably since the last inspection, and have made the exposure in that direction somewhat confined. The instruments should be moved to a more open situation. On comparing the earth thermometers it was found that the zeros of those at 2ft. and 4ft. had risen 0°·4. I was unable to compare the thermometers at 3 and 6 inches.

BEDDINGTON, *August 27th.*—As Mr. Rostron contemplated leaving his house in Beddington Lane at the end of September, I went on this date to his new residence at Riverside and selected a site for the thermometer screen

and rain-gauge. The site chosen is in the kitchen garden, and is well exposed. The garden is close to the river Wandle.

BENNINGTON, *August 29th.*—All the instruments were in good order. The thermometer screen and rain-gauge were moved in March last about 20 feet North-east of their former site. A rearrangement of the thermometers in the screen was suggested, so that they might be in accordance with the plan recommended in the *Hints to Observers.*

BERKHAMSTED, *August 31st.*—The instruments are well exposed on a grass-plot in a rose garden. The ground slopes about 1 in 7 from North-north-east to South-south-west. Everything at this station was clean and in good order. In addition to the usual instruments, Mr: Mawley has a barograph, thermograph, anemograph, recording rain-gauge, and percolation gauges for light and heavy soils.

BRIGHTON, *August 22nd.*—I visited this station at the request of Dr. Newsholme, the recently-appointed Medical Officer of Health, who was desirous of reorganising the meteorological observations. The instruments are in the Steyne Gardens. I recommended that they should be moved further from the fountain, so as to be out of the influence of the spray, and also that the thermometers should be sent to Kew for reverification. A sunshine recorder will be placed on the roof of the Town Hall.

EASTBOURNE, *August 23rd.*—The instruments are placed in a large kitchen garden at the back of a house in Sea Side Road. The exposure is good, the only obstruction being a tree on the South-south-west, which makes an angle of 40° with the rain-gauge. The instruments were all in good order, except the minimum thermometer, which had some spirit at the top of the tube.

GUERNSEY, *July 20th.*—The instruments were in good order. I recommended that a cover be placed over the water receptacle of the wet bulb thermometer. On comparing the thermometers it was found that the zero of the wet bulb had risen 0°·1.

HARESTOCK, *July 24th.*—All the instruments were clean and in very good order.

HASTINGS, *August 23rd.*—Since the last inspection the thermometer screen has been moved to a more favourable situation. The rain-gauge has also been moved, and is now placed on a wall, as its former site has been built upon. The thermometers were all correct, except the minimum, which had 0°·7 of spirit at the top of the tube.

HILLINGTON, *September 13th.*—At the time of my visit the wet bulb thermometer was not working properly, the bulb being dry. The thermometers were all correct.

KENILWORTH, *August 30th.*—The minimum thermometer had 0°·8 of spirit at the top of the tube. The thermometer screen required painting.

LINCOLN, *September 14th.*—Since December 1887 the electrical thermometer on the great tower of Lincoln Cathedral has been under the care of Mr. C. J. Bromhead. In the early part of this year the instrument was thoroughly overhauled by the staff of the Postal Telegraph Department,

since which time it has appeared to be working very well. The other meteorological instruments have been removed from Mr. Mantle's to Mr. Bromhead's garden, which is only a short distance South-west of the Cathedral. The observations are taken twice daily, viz. at 9 a.m. and 6 p.m.

LOWESTOFT, *September 10th.*—The garden wall has been set back since the last inspection, so that a larger area has now been enclosed. The exposure is fair, although somewhat confined. The instruments were in good order. On comparing the thermometers it was found that the minimum read 0°·2, and the grass minimum 0·3° too low.

MARGATE, *August 24th.*—At the time of my visit the wet bulb thermometer was not working properly, the bulb being dry. The other instruments were in good order.

MARLBOROUGH, *July 17th.*—The instruments were in good order except the grass minimum, which had some spirit at the top of the tube. Arrangements have been made for carrying on the observations during the holidays.

OLD STREET, LONDON, *September 27th.*—On comparing the thermometers it was found that the zero of the dry bulb had risen 0°·1. The rain-gauge is very much corroded, and will soon require to be replaced by a new one.

PORTSMOUTH, *July 25th.*—The thermometer-screen and rain-gauge have been moved a little further north since the last inspection, and now have a more open exposure. The minimum thermometer had a little spirit at the top of the tube.

RAMSGATE, *August 24th.*—The instruments were in good order, except the minimum thermometer, which had 1°·1 of spirit at the top of the tube.

REGENT'S PARK, *September 27th.*—On comparing the thermometers it was found that the minimum read 0°·4 too low.

SOMERLEYTON, *September 11th.*—The minimum thermometer had 0°·9 of spirit at the top of the tube. On comparing the thermometers it was found that the zero of the wet bulb had risen 0°·8.

SOUTHAMPTON, *July 17th-18th.*—All the instruments were in good order. The zero of the dry bulb thermometer had risen 0°·2. A new rain-gauge has been set up and is read monthly. The Rev. H. Garrett has a number of earth thermometers; and at the bottom of the tubes he has placed some glycerine or castor oil into which the bulbs of the thermometers dip.

SOUTHBOURNE, *July 18th.*—Dr. Compton has given up his house, Locksley, but the instruments are still there and are duly read by one of his men. The instruments were in good order. Dr. Compton now lives on the Undercliff, and has fixed a thermometer-screen on the parade. He also proposes placing another screen on the road to Christchurch, at the same height above sea-level as that on the parade.

STRATHFIELD TURGISS, *July 16th.*—The thermometers are placed in the old Kew stand, as the Stevenson screen has been lent to the Duke of Wellington. The rain-gauge is mounted on a post 8 feet above the ground, and has been in the same position since 1858. The currant bushes, &c. had grown up very much all round the instruments; the observer was, therefore,

requested to have them cut back. The thermometers were all correct, except the maximum, which had gone up 0°·2. The tube of the maximum thermometer had slipped a little, so that the divisions did not correspond with those on the scale. This I set right by readjusting the tube.

SWARRATON, *July 24th.*—On comparing the thermometers it was found that the dry, wet, and maximum had each risen 0°·1.

VENTNOR, *July 26th.*—The thermometers were all correct and in good order. The sunshine recorder is kept by Mr. W. Kilburn, at St. Lawrence. This is an old pattern instrument with a movable strip of metal for holding the card. Owing to the aspect of the Undercliff the sun does not shine on the recorder till within a quarter of an hour after sunrise nor after 6 p.m. in summer.

WEYMOUTH, *July 19th.*—All the instruments were in good order, and the thermometers correct.

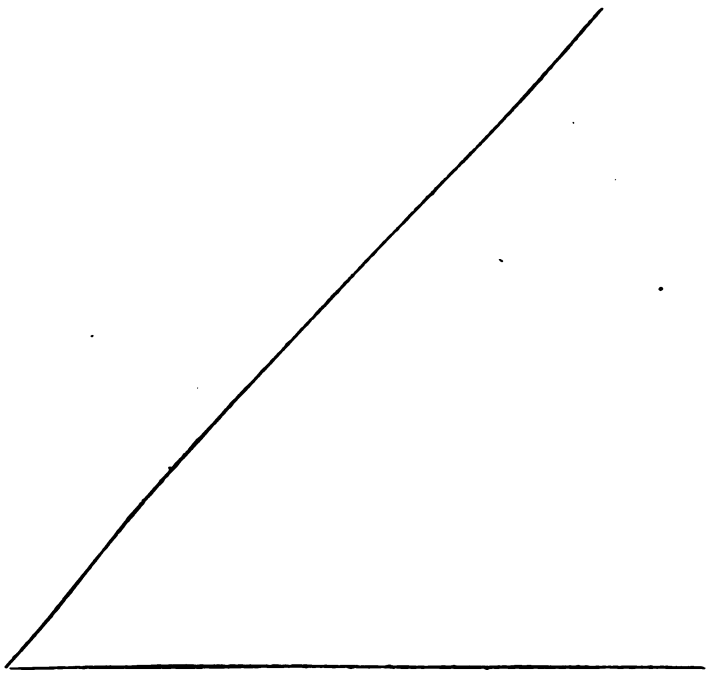
WORTHING, *July 27th.*—Dr. Harris has moved from the Marine Parade to Heene, which is about a mile and a half West-north-west of the former place and half a mile from the sea. The instruments are placed on the lawn in a well-exposed situation. All the thermometers were correct except the earth thermometer, which had gone up 0°·2. Dr. Harris has also organised a station at the Worthing Infirmary, which is about a quarter of a mile from the sea. The instruments are placed on the lawn and have a good exposure.

APPEN-

STATEMENT OF RECEIPTS AND PAYMENTS

Receipts.

	£	s.	d.	£	s.	d.
Balance from 1887				217	17	0
Subscriptions for 1888	623	5	8			
Do. former years	39	4	0			
Do. paid in advance	51	4	0			
Life Compositions	42	0	0			
Entrance Fees	51	4	0			
				806	17	8
Meteorological Office:—Copies of Returns	103	5	3			
Do. Grant towards Inspection Expenses	25	0	0			
				128	5	3
Dividends on Stock				61	14	11
Sale of Publications				38	16	0



£1253 10 10

DIX III.

FOR THE YEAR ENDING DECEMBER 31ST, 1888.

PAYMENTS.

	£ s. d.	£ s. d.
Journal &c.:—		
Printing Nos. 65 to 68	157 3 6	
Illustrations	27 8 5	
Authors' Copies	17 11 0	
Meteorological Record, Nos. 27 to 30	48 3 6	
Registrar-General's Reports	8 8 0	
		258 14 5
Printing, &c.:—		
General Printing	22 17 0	
List of Fellows	10 15 0	
Forms	12 0 0	
Stationery	15 3 9	
Books and Bookbinding	27 6 11	
		88 2 8
Office Expenses:—		
Salaries	317 6 0	
Rent and Housekeeper	48 16 6	
Repairs, Coals, &c.	8 8 9	
Postage	44 2 8	
Petty Expenses	10 13 4	
Refreshments at Meetings	13 16 3	
Exhibition of Instruments	9 6 6	
		452 10 0
Observations:—		
Inspection of Stations	36 11 0	
Observers at Old Street and Seathwaite	7 2 0	
Instruments	3 8 9	
Wind Force Experiments	13 14 1	
		60 15 10
Stock:—		
Purchase of £50 New 3 per Cents.		51 3 9
		911 6 8
Balance:—		
At Bank of England	319 6 7	
In hands of Assistant-Secretary	22 17 7	
		342 4 2
		£1253 10 10

Examined and compared with the Vouchers, and found correct,

J. S. HARDING,
H. SOWERBY WALLIS, } *Auditors.*

January 10th, 1889.

APPENDIX III.—Continued.

ASSETS AND LIABILITIES ON JANUARY 1ST, 1889.

LIABILITIES.

	£	s.	d.
To Subscriptions paid in advance	51	4	0
,, Excess[1] of Assets over Liabilities	2426	13	0
	£2477	17	0

[1] This excess is exclusive of the value of the Library and Stock of Publications.

ASSETS.

	£	s.	d.	£	s.	d.
By Investment in M. S. and L. R. 4½ Debenture Stock, £800 at 139	1112	0	0			
,, Investment in N. S. W. Stock 4 per Cent. £500 at 115¼	576	5	0			
,, Investment in 2¾ per Cent. Consols, £250 at 97¾	244	7	6			
				1932	12	6
,, Subscriptions unpaid, estimated at	60	0	0			
,, Entrance Fees unpaid	4	0	0			
,, Interest on Stock	29	0	4			
				93	0	4
,, Furniture, Fittings, &c.	35	0	0			
,, Instruments	75	0	0			
				110	0	0
,, Cash in hands of Bank of England	319	6	7			
,, ,, the Assistant Secretary	22	17	7			
				342	4	2
				£2477	17	0

J. S. HARDING,
H. SOWERBY WALLIS, } *Auditors.*
WILLIAM MARRIOTT, *Assistant Secretary.*

January 10th, 1889.

APPENDIX IV.

OBITUARY NOTICES.

JOHN RAND CAPRON was born in London, February 19th, 1829. He was educated at the Grammar School, Guildford, and on completing his studies was articled to his uncle, Mr. John Rand, a solicitor in extensive practice in that town. After being admitted a solicitor, in 1850, Mr. Capron entered into partnership with his uncle, and subsequently succeeded to the business. He was soon appointed Borough Coroner and Clerk of the Peace, which latter appointment he held up to the time of his death.

In the midst of his many business cares and public engagements Mr. Capron found leisure to gratify his enthusiasm for the study of natural phenomena, and it is as a scientific man of some distinction that his name will be best remembered. When at school he had a severe attack of typhoid fever, and during his convalescence a compound microscope was lent to him. This opened out a new world of wonder and beauty, and was the means of firing his ambition to examine some of the fascinating mysteries of creation. He took a special interest in studying the earth's surface, making considerable progress in geology, and forming a collection of fossils and minerals of great interest and variety. But later on he turned his attention to spectroscopy and meteorological phenomena, and became a devoted student of astronomy.

In 1877 Mr. Capron published an important work on *Photographed Spectra*, in which he gave, in a very easy and convenient form for reference, 186 photographs of metallic, gaseous, and other spectra, accompanied by critical explanations. For obtaining the spectra of the metals he employed a direct vision prism of an inch aperture, with collimator and camera, and with this spectroscope he obtained photographs of the spectra of some forty metals, extending from about *b* to H. For most of these metals two photographs were obtained—one taken with the induction spark, and the other with the electric arc from a battery of 40 pint Grove cells. For the spectra of gases, three different spectroscopes were employed, one of these having two simple quartz prisms of 60°, and the others each a direct vision prism of large size. The value of this work was fully recognised at the time, as it brought together so many spectra simultaneously before the eye, thus giving a far greater insight into their physical characteristics than could so readily be obtained by a study of the individual spectra with the spectroscope one after the other.

In 1879 Mr. Capron published a popular treatise on *Auroræ and their Spectra*. In this work he presented a very complete history of early and recent observations of auroral phenomena, in which he carefully records the general appearance and special characters of the aurora; its geographical distribution; colours, height, and noises attributed to it; phosphorescence, polarisation of its light, &c. The most valuable part of the work is that devoted to an investigation of the auroral spectrum. The subject is very carefully and exhaustively discussed, and the author's long series of labora-

tory experiments to elucidate and explain some of the obscure phenomena of the aurora will always be of value.

In an interesting pamphlet published in 1882, Mr. Capron called particular attention to the subject of the "*Rainband*," and the importance of observing it as indicative of the presence or otherwise of an excess of moisture in the atmosphere.

Mr. Capron was a man of the most beneficent and philanthropic character, and took much interest in all the social institutions of his neighbourhood. He subscribed to a large number of charities, and was ever ready, though in the most unostentatious manner, to afford aid and succour to those in poverty and distress.

He had been in failing health for some time past, but his illness took a more serious turn in October, and he passed away on November 12th, 1888, at the age of 59 years.

Mr. Capron was elected a Fellow of this Society on February 15th, 1882.

Surgeon-Major WILLIAM CAREY COLES, M.D., was a son of the Rev. Thomas Coles, of Bourton-on-the-Water, Gloucestershire, where he was born on July 25th, 1817. He received his medical education at University College, the College of Surgeons, and Apothecaries' Hall, London, taking the Fellows' gold medal and his diplomas in 1839-40. Between the latter year and 1843 he served on board the Honourable East India Company's troopship *Minerva* in the Eastern Seas, receiving two silver medals, one for the China War and the other for the taking of Canton. On his return to England he took the degree of M.D. at Edinburgh, in 1844, and in the following year, on the recommendation of the late Mr. J. E. Carruthers and the nomination of Major Oliphant, obtained his commission from the court of directors as an assistant-surgeon in the Bombay Army.

For several years Dr. Coles was employed in various appointments on general duty, serving at different times with the 78th Highlanders, the 20th Bombay Native Regiment, and the Madras Artillery; and as assistant civil surgeon and surgeon to the coroner and garrison surgeon at Bombay. In 1849 he was appointed Professor of Midwifery and Medical Jurisprudence in the Grant Medical College, and held these appointments until 1854, acting for some time in 1852-3 as Principal of the College during the absence on furlough of the late Dr. Herbert Giraud. Having frequently acted from 1848 as secretary to the Bombay Medical Board, he was permanently appointed to that office in April 1855, and continued to hold it to his retirement from the service in 1865.

It was in this position that Dr. Coles made his reputation as an administrative officer of the highest efficiency and distinction. To great natural capacities for such duties as were now required of him he added habits of the most indefatigable self-denying industry and of the exactest regularity in the distribution and despatch of his work. He was, moreover, a man of great dignity of presence and benevolence of character, and of the most genial and engaging manner; and he thus became one of the most marked

personalities in the official and social life of Western India during the last years of the East India Company's rule and before "old Bombay" was transformed, under Sir Bartle Frere, as if by magic, into the magnificent maritime city, the Venice of the Indian Ocean, known to the present generation of Englishmen. So highly and so gratefully were the services of Dr. Coles as secretary to the Medical Board appreciated by his brother officers, that on his finally leaving India he was presented by them with a service of silver, which was intended to commemorate in particular his successful administration of the medical retiring fund under the greatest difficulties.

Dr. Coles employed his latter years, since 1865, in actively interesting himself in the cottage hospital and meteorology and the educational and general Church work of his native parish, where he died on May 17th, 1888, in the 71st year of his age.

He was elected a Fellow of this Society on January 15th, 1879.

Major George Graham was the fourth son of Sir James Graham, first baronet, of Netherby, Cumberland, and was born in 1801. From 1828 to 1830 he was Military Secretary at Bombay. He acted as private secretary to his brother, the late Sir James Graham, who was First Lord of the Admiralty from 1831 to 1834 and Secretary of State for the Home Department from 1841 to 1842.

Major Graham held the office of Registrar-General of Births, Deaths, and Marriages from 1838 to 1879.

He died after a short illness on May 20th, 1888.

Major Graham was elected an Honorary Member of this Society on March 27th, 1855.

Samuel Elliott Hoskins, M.D., F.R.S., was born in Guernsey on February 7th, 1799. His father was of Devonshire descent, his mother's family was of Jersey notability. But the remarkable success which attended Dr. Hoskins from the beginning of his career was as much due to education as to inheritance. With praiseworthy forethought his parents conducted his instruction until he was old enough to go to a school near Exeter, and they seem to have imbued him with that love of home which in later life gained him for his native island. He was first destined for the Guernsey Bar, and he began his preparation work under Advocate Charles de Jersey, afterwards H.M. Procureur. After a year's trial the offer of a pupilage with Drs. Monk and Brock was more congenial to him, and by their guidance, and with the help in classics of the Rev. Thomas Grut, he was in the year 1818 enrolled as a student at the united Hospitals of Guy's and St. Thomas's.

A student's honours in those days were not represented by parchment or money prizes, but Hoskins won for himself the esteem and life-long friendship of such men as Astley Cooper, George Henry Green, Bransby Cooper, Charles Ashton Keye, and in the literary world, of Coleridge, Charles Lamb, De Quincey, and Thomas Noon Talfourd. One must realise what the world was then to glean what such companionship meant to a country youth.

Armed with the license of the Apothecaries Company, and the membership of the Royal College of Surgeons, he even refused the offer of an assistant surgeoncy in the Foot Guards, and returned to Guernsey to become the partner of Dr. Brock. In 1827 he spent three months in Paris, which gave a powerful bias to his future. Magendie, Dupuytren, Laennec, and Civiale were then fervently pushing their investigations, and welcomed the matured student who brought them letters of introduction.

On his return to Guernsey Hoskins side by side elaborated a chart of stethoscopic signs, and an investigation into the solubility of calculi within the body. The former was published in London, favourably reviewed by the *Lancet*, and rapidly passed into a second edition. The latter occupied many years of his life, and was associated with his translation of Scharling's work on Calculi, which was published in 1841. His results, presented to the Royal Society in 1843, gained him his election to the Fellowship. His other high professional honour was the Fellowship of the Royal College of Physicians, to which he was elected in 1859.

If we exclude a very clever research into the causes of the failure of the percussion caps of the 46th Regiment (the results of which were confirmed by Faraday, and approved by the great Duke of Wellington), all Dr. Hoskins' further work was associated with Guernsey. His best known observations concern the climatology of the island. They were at the time unique, and are still quoted with well-merited respect. His paper on the "origin and progress of cholera and small-pox in 1849" was written at the request of the Epidemiological Society. His work entitled "Charles the II. in the Channel Islands" is well known, his smaller papers on "the carved oak chests of the Channel Islands" and "on the outposts of England" less so. But it was in acknowledgment of his paper on oak chests that Douglas Jerrold sent him "some cwt. of *Punch*" to adorn "the gorgeous oak shelves of which it is all too unworthy."

To the end of his life Dr. Hoskins never lost the fever for historical research, and when far advanced in his eighth decade not only did the pages of the *Guernsey Magazine* record fresh facts, but Mons. Charles Hettier, in his work entitled *Relations de la Normandie et de la Bretagne avec les Iles de la Manche*, sought the assistance of, and paid tribute to, the worth of the aged historian.

About 1859 he retired from active professional life.

Dr. Hoskins' later years form a fitting counterpart. He lived to complete his historical writings and to utilise his meteorological observations. He lived his younger days over again in the writings which have now become classics, and even in this year (1888) he conned with excited interest Walter Besant's *Fifty Years Ago*, a book which to one of his histrionic tendencies was specially palatable. Few men reach the contentment which is great gain. Dr. Hoskins was one of the few. He lived his life and laid it down with the satisfaction that he had not been born in vain.

He died on October 12th, 1888, aged 89 years.

Dr. Hoskins was elected a Fellow of this Society on May 7th, 1850.

Colonel ARTHUR SWANN HOWARD LOWE was the youngest son of Mr. A. Lowe, J.P., and was born on December 4th, 1826, at Highfield House, near Nottingham. He received his early education at Mr. Fletcher's School in Nottingham, and with private tutors at home.

In 1852 he entered the Nottingham Militia, and eventually became Colonel of that regiment, which he commanded up to the summer of 1887, when failing health compelled him to resign. During this long period of service he took a very active interest in everything that concerned the welfare and satisfactory condition of his regiment.

Colonel Lowe was greatly interested in all scientific pursuits, taking regular meteorological observations and watching astronomical phenomena with much zeal. He rendered material assistance to his brother, Mr. E. J. Lowe, F.R.S., in the preparation of a work on *The Climate of Nottingham*. He was an excellent draughtsman, and undertook many illustrations of birds and their eggs. All the drawings of freshwater Mollusca, published in *The Conchology of Nottingham*, were made by him.

Colonel Lowe was for many years a Life Member of the British Association, and also a Fellow of the Royal Astronomical Society. He was a magistrate for the county of Essex, and resided at Gosfield Hall, Halstead, where his death took place on August 4th, 1888, after some months' illness.

He was elected a Fellow of this Society on May 7th, 1850.

JOHN MCLAREN was a native of the parish of Methvin, Perthshire, and came south with Lord Lynedoch nearly fifty years ago. For many years he was a true and faithful servant of the Whitbread family at Cardington, near Bedford, and in him were reposed the confidence and esteem of those in whose service he was. He commenced his records of meteorological observations, as assistant to the late Mr. Samuel Charles Whitbread, F.R.S., in 1846, and with one or two brief intervals he continued them to the end of his life. Mr. McLaren was an able and accomplished botanist, and his collection of local plants is of an extensive and reliable character. Of Mr. McLaren it may be truly said that he never lost a friend or made an enemy. Quiet and unassuming in his manner, he was a man of great knowledge, and he was highly respected by all who knew him.

He died on July 7th, 1888, in the 78rd year of his age.

Mr. McLaren was elected a Fellow of this Society on May 7th, 1850.

The Rev. PHILIP HANKINSON NEWNHAM, M.A., was a man of singular power of mind and spirit. His information on many subjects, especially of a scientific sort, was surprising, and soon revealed itself in conversation. He took great interest in meteorological matters, frequently instituting a discussion of various phenomena, and for at least one year, when residing at Bournemouth, took hourly readings, during the day hours, of the dry and wet bulb thermometers. His climatological observations at Maker from 1880-86, and at Exeter from 1886-88, were printed in the *Meteorological Record*.

Mr. Newnham delighted in statistics. He could tell at almost a glance

how many and who were at church at any service, and would perhaps astonish any one after service by comparing the attendance with the same Sunday the previous year, remarking possibly some strange coincidence between the two Sundays or the persons present. The names of communicants, candidates for confirmation, Sunday scholars, &c. were enrolled year by year in records of exquisite neatness, and when once the mysteries of blue and red lines and points were explained, the story of their attendances, with sudden stops and sad gaps, was revealed at a glance.

He was for some time pastor at St. George's, Stonehouse, and for eleven years held the vicarage of Maker, which he left in July 1886 to take up the chaplaincy of the Devon and Exeter Hospital. He was for many years a great sufferer, and carried on his pastoral work with much difficulty and pain. He died at Teignmouth on November 6th, 1888, in the 56th year of his age.

He was elected a Fellow of the Royal Meteorological Society on April 17th, 1867.

William Roper was one of the oldest members of the Lancaster Corporation, and soon after his election as Town Councillor he became conspicuous as one of the hardest workers, devoting his attention chiefly to the provision of a complete and effective water supply for the town and neighbourhood. It was mainly through his efforts that in 1876 the water supply system was enlarged, and that in 1880 the enlargement was completed, so that it is now sufficient to meet all the requirements of the town for many years to come.

Mr. Roper took a close and controlling interest in the management of the gas-works for the town for several years, as Chairman of the Gas Committee of the Corporation; and he was also Chairman of the Morecambe Gas Company.

Mr. Roper was Mayor of Lancaster in 1869-70, and was made a Justice of the Peace for the Borough of Lancaster in 1885. He was also a member of the Port Commission, and was well known and highly respected as one who discharged many public duties with extreme courtesy, kindness and consideration. He was an indefatigable worker, and after the great object of his public life had been attained—the completion of the Lancaster water-supply—he employed himself in meteorological studies. He issued several little works relative to the rainfall and weather in Lancaster and the district.

Mr. Roper died on April 6th, 1888, in the 68rd year of his age.

He was elected a Fellow of the Royal Meteorological Society on May 18th, 1881.

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1888.

Presented by Societies, Institutions, &c.

ADELAIDE, MARINE BOARD OF SOUTH AUSTRALIA.—Report for 1887.

ALGIERS, SERVICE MÉTÉOROLOGIQUE ALGÉRIEN.—Quantités de pluies recueillies en Algérie, 1877-1886.

ALLAHABAD, METEOROLOGICAL OFFICE.—Annual Statement of Rainfall in the North-western Provinces and Oudh, 1887.

BATAVIA, MAGNETICAL AND METEOROLOGICAL OBSERVATORY.—Observations made during 1886.—Rainfall in the East Indian Archipelago, 1886.

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HOPKINSON, J.—A Sketch of the Geology and Climate of Hertfordshire, with notes on its botanical districts.—Meteorological Observations taken at Throcking, Herts, during 1884 to 1886. By Rev. C. W. Harvey.—Meteorological Observations taken at Watford during 1877, 1885, and 1886.—Report on Phenological Phenomena observed in Hertfordshire during 1885 and 1886.—Report on the Rainfall in Hertfordshire in 1884 to 1886. By Rev. C. W. Harvey.

HUNTER, J.—Meteorological Observations at Belper, 1888.

JACKSON, W. E.—Meteorological Observations made at Erenkeuy, Constantinople, Dec. 1887 to Nov. 1888. (MS.)

KAMMERMANN, A.—Résumé Météorologique de l'année 1887 pour Genève et le Grand Saint-Bernard.

LANCASTER, A.—Le Climat de la Belgique en 1887.—Tableaux-Résumés des Observations Météorologiques faites à Bruxelles 1833-1882, II. Pression de l'air.

LAWSON, R., LL.D.—The Milroy Lectures on Epidemic Influences.

LEE, G. J.—Incwadi Yami, or Twenty Years' Personal Experience in South Africa. By J. W. Matthews, M.D.—Meteorological Observations made at Kimberley, South Africa, Nov. 1887 to Oct. 1888. (MS.)

LEUPOLD, H.—Weather Maps of Davos Platz, Jan. to Dec. 1887.

LLOYD, H. J.—Meteorological Observations made at Barmouth, 1888. (MS.)

MALAN, REV. A. H.—Meteorological Observations made at Altarnun, 1888. (MS.)

MANN, MRS.—Sketch of the Life and Work of Dr. Mann.

MARILAUN, F. K. v.—Untersuchungen über die Schneegrenze im Gebiete des mittleren Innthales.

MASSIE, ADMIRAL T. L.—Meteorological Journals kept by R. Massie at Pulford Hall, near Wrexham, 1862-1887. (MS.)

MAWLEY, E.—Meteorological Observations taken at Berkhamsted, April 19 to Dec. 27, 1887.—The Rosarian's Year Book, 1888.

MCADIE, A.—Atmospheric Electricity at high altitudes.—William Ferrell.

MCLANDSBOROUGH, J., AND PRESTON, A. E.—Meteorology of Bradford for 1887.

MERRIFIELD, DR. J.—Meteorological Summary for the year 1887 at Plymouth.

MIDGLEY, W. W.—Fall of Rain at Bolton, Belmont, Heaton, Entwhistle, Blackpool, &c. for the year 1887.

MILLER, MISS.—Meteorological Register for the years 1826 to 1855, kept by the Rev. J. K. Miller, Vicar of Walkeringham, Notts. (MS.)

MOHN, PROF. H.—Studier over Nedborens Varighed og Toethed i Norge.—Tordenvejrens Hyppighed i Norge, 1867-1883.

MOHN, PROF. H., AND HILDEBRANDSSON, H.—Les Orages dans la Péninsule Scandinave.

MOUSSETTE, C.—Orage du 12 Mai 1886. La foudre en spirale.

NEWNHAM, MRS.—Miscellaneous Meteorological Memoranda collected by Rev. P. H. Newnham. (MS.)

NIPHER, F. E.—The volt, the ohm, and the ampere.

ORMEROD, G. W.—Rainfall at Teignmouth, 1887.

PAGE, DR. H.—Meteorological Observations made at Redditch, 1887. (MS.)

PEARSON, C. N.—Meteorological Observations made at Reading, 1888. (MS.)

PERIGAL, F.—Some account of the Perigal Family.

PRESTON, REV. T. A.—The Flowering Plants of Wilts, with sketches of the Physical Geography and Climate of the County.

PRINCE, C. L.—The Summary of a Meteorological Journal kept at Crowborough, Sussex, 1887.

PRINZ, W.—Etude de la structure de l'éclair par la photographie.

RADFORD, DR. W. T.—Climate of Exeter, 1829-1836. By Dr. T. F. Barham.—Lehrbuch der Meteorologie. Von Prof. L. F. Kämtz.

RAGONA, PROF. D.—Pressione Atmosferica Bi-Oraria del 1887 tratta dai rilievi del barometro registratore Richard.

RICCO, PROF. A.—Riassunto delle osservazioni e studii dei grandi crepuscoli rosei.

RIGDEN, B.—Canterbury Weather, 1887.

ROTCH, A. L.—Summary of Observations for 1887 made at Blue Hill Meteorological Observatory, Mass.—The new mountain meteorological stations on the Sonnblick and Sentis.

RYVES, REV. G. T.—The Weather of 1887.

SALLE, OTTO.—Das Wetter, Jan.-Dec. 1888.

SCOTT, R. H.—On Recent Progress in Weather Knowledge (1873).—On the Connection between Air-currents and subsequent weather.—On the employment of a Planimeter to obtain mean values from the traces of continuously self-recording meteorological instruments.—On the Work of the Meteorological Office, Past and Present (1869).—Storms in the British Islands, and Telegraphic Weather Intelligence. By R. H. Scott.—The Results of Recent Meteorological Inquiry (1873).

SHAW, REV. G.—Meteorological Observations made at Farafangana, Madagascar, Oct. 1888. (MS.)

SIEMENS BROTHERS, MESSRS., & Co.—Magneto-Inductor and Bridge for testing Lightning Conductors.

SLADE, F.—Meteorological Observations for 1887 taken at Beckford, Tewkesbury.

SMITH, H.—Rainfall at Hull, 1857-87.

SMITH, REV. E. B.—Meteorological Observations made at Ramsgate, 1888. (MS.)

SMITHSON, T. S.—Meteorological Observations made at Facit, Rochdale, 1888. (MS.)

SMYTH, C. PIAZZI.—Report on the state of the Royal Observatory, Edinburgh, June 1888.—The Edinburgh Equatorial in 1887.

STANLEY, W. F.—Mathematical Drawing and Measuring Instruments.

STRACHEY, GEN. R., F.R.S.—Meteorology of the Red Sea and Cape Guardafui.

SWINTON, A. H.—The Laws of Cyclones. (MS.)

SYMONS, G. J., F.R.S.—Symons's British Rainfall, 1887.—Symons's Monthly Meteorological Magazine, 1888.—The Floating Island in Derwentwater.

TAYLOR AND FRANCIS, MESSRS.—Taylor's Calendar of the Meetings of Scientific Bodies of London for 1888-89.

THE EDITOR.—American Meteorological Journal, Dec. 1887 to Nov. 1888.

THE EDITOR.—Ciel et Terre, Deuxième Série, Vol. III. No. 21 to Vol. IV. No. 20.

THE EDITOR.—Nature, Nos. 949 to 1000.

THE EDITOR.—Scientific News, New Series, Vols. I. and II.

THE EDITOR.—Telegraphic Journal and Electrical Review, Nos. 528 to 579.

THE EDITORS.—The Observatory, Nos. 132 to 144.

TOYNBEE, CAPT. H.—Deuxième Campagne Scientifique de "l'Hirondelle" dans l'Atlantique Nord, par Prince A. de Monaco.—Sur des courbes barométriques enregistrées pendant la troisième campagne scientifique de "l'Hirondelle," par Prince A. de Monaco.

TRIPE, DR. J. W.—Report on the Sanitary Condition of the Hackney District for the year 1887.

TRIPP, REV. C. U.—Yearly Rainfall at Altarnum Vicarage, Cornwall, 1864-87.

TRIPP, W. B.—Statistics of the Colony of New Zealand, 1885.

TURTLE, L.—Review of the Weather of 1887 at Aghalee, Co. Antrim.

TYRER, R.—Rainfall in the County of Gloucester, Jan. to Nov. 1888.—The Climate of Cheltenham during the years 1878-1887.—The Meteorology of Cheltenham, 1887.

UPTON, W.—The Storm of March 11-14, 1888, in New England.

UPTON, W., AND ROTCH, L.—Meteorological Observations during the Solar Eclipse, Aug. 19, 1887, made at Chlamostino (near Iwanowo), Russia.

VELSCHOW, F. A.—The natural Law of Relation between Rainfall and Vegetable Life and its application to Australia.

WAGNER, PROF. C.—Niederschläge und Gewitter zu Kremsmünster.

WATSON, REV. J.—Meteorological Observations made at Sedbergh, 1888. (MS.)

WEIHRAUCH, PROF. K.—Neue Untersuchungen über die Bessel'sche Formel und deren Verwendung in der Meteorologie.

WELLS, J. G.—Burton-on-Trent Meteorological Summary for 1886.—Meteorological Observations made at Burton-on-Trent, 1888. (MS.)

WHIPPLE, G. M.—Note on the Verification of Thermometers at the freezing-point of mercury.

WIGERT, T.—Orage accompagné de Trombes près Upsala.

WILD, DR. H.—Die Regen-verhältnisse des Russischen Reiches; mit einem Atlas.

WOEIKOF, DR. A.—Klima des Ben Nevis in NW Schottland.—Klimatologische Zeit-und Streitfragen II. and III.

WOOD, T.—Meteorological Observations made at Gwernyfed Park, 1888. (MS).

WORTH, J. E.—The Meteorology of Burslem for 1887.

ZENGER, PROF. CH. V.—La Période Solaire, les essaims d'Etoiles Filantes et les Perturbations Magnetiques.

APPENDIX VI.

REPORTS OF OBSERVATORIES, &c.

THE METEOROLOGICAL OFFICE.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of the Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav.-Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

The only change in the administration of the Office during the year has been caused by the retirement in July of Captain Toynbee, who had held the post of Marine Superintendent for nearly 22 years. He has been succeeded in the office by Mr. Baillie.

Marine Meteorology.—The publication of the Daily Charts of Atlantic Weather for the thirteen months ending with August 1883 is now complete. The daily charts of the North Indian Ocean for the interval of six weeks about the time of the Aden Cyclone in May 1885 are in an advanced stage of preparation, and will appear in the present year.

The Meteorology of the Ocean in the vicinity of Cape Guardafui.—The Office has undertaken a detailed examination of the records especially of Sea Temperature around the extreme North-east point of Africa, Cape Guardafui, which bears an evil reputation from the frequency of wrecks in its neighbourhood. It has been more than once asserted that the sea surface temperature gives sufficient intimation to a seaman of his precise position. The Council have, therefore, directed that this subject be thoroughly investigated, and charts are accordingly being prepared, representing the special meteorological features of the district for each month of the year.

The inquiry on the *Meteorology of the Red Sea* continues to make satisfactory progress. The charts of the Cyclone Tracks of the Indian Ocean are nearly ready for publication. The only delay is caused by the fact that the corrected data for three years have not yet arrived from the Mauritius.

The inquiry on the Currents of the Ocean has been continued throughout the year. It is of a protracted character, from the large amount of material to be dealt with.

Part V. of the *Contributions to the Meteorology of the Arctic Regions* has now appeared. It deals with the Meteorology of Behring Straits, including Point Barrow. With this part the discussion of all the winter records collected during the Franklin Search Expeditions has been brought to an end.

Weather Telegraphy.—There has been no change of importance in this department during the year.

The Weekly Weather Report was issued on the same lines as the volume for 1887. With the commencement of 1889 the size of this periodical has been materially increased, from four pages to six. The area embraced by the charts given in it has been much enlarged, and now extends Eastwards so as to include Archangel, Moscow and Constantinople, and Southwards to take in Algeria. The conspectus of weather includes nearly the whole of Europe.

Fishery Barometer Inspection.—The Council have given directions for an inspection to be undertaken of the Fishery Barometers on the coast, 167 in number. Many of these have been visited, and in most instances it is found that they are in good order and well cared for.

The receipt of weather telegrams from the United States has been discontinued, as it has been found by independent investigation both in this country and in France that their utility is practically *nil.*

Land Meteorology of the British Isles.—The Quarterly Weather Report for 1879 has been completed, and the Hourly Readings up to March 1886 have appeared. The discussion by means of the Harmonic Analyser of the Barograms has been carried on up to the year 1881, and some special work has been done with the instrument in order to throw light on the causes of the diurnal oscillation of the barometer.

The volume of the *Observations of Stations of the Second Order* for 1884 has appeared, and that for 1885 is in the press.

The Meteorological Tables for the Registrar-General in Ireland have been, as usual, prepared in the Office.

The printing of the returns for Foreign and Colonial Stations from the records of the Royal Engineers and the Army Medical Department has now been commenced, and the volume may be expected to appear ere very long.—*February 4th*, 1889.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal.—During the year 1888 no changes of instruments or of methods have taken place in the Magnetical and Meteorological Department of the Observatory.

The observations of the temperature of the air in a Stevenson screen and on the roof of the Magnet House are still continued. The minimum temperature in the screen is generally higher than that observed on the ordinary stand, and the maximum lower, especially in the summer months. Full details of these observations will be found in the printed volumes, the printing of that for 1887 being now nearly complete.

The Thomson Electrometer has given some trouble. In the autumn of the year 1888, having been in use for ten years, it received thorough cleaning and was compleley renovated by Messrs. Elliott, but with the effect of altogether changing its indications. The scale appears to be very much contracted, and in other particulars there seems to be change, the cause of which we have not been able to trace.

The new thermograph has been continuously in use and gives great satisfaction, and the Richard thermograph is found to be a very useful instrument for continuous registration of the temperature of the Magnet Basement. We have found a small electric lamp very convenient for making eye observations of temperature in the Basement.

In the autumn of 1888, the pressure springs of Osler's Anemometer were found to be in an unsatisfactory state from perishing of the metal of the weaker springs, and in October they were removed. The springs were entirely renewed by Messrs. Troughton and Simms, and record with the new springs commenced on December 12th. As regards the measurement of pressures by Osler's Anemometer, it may be mentioned that in the year 1882 the rather stiff copper wire connecting the pressure plate with the recording pencil was removed, and replaced by a fine brass chain, which being perfectly flexible has given greater accuracy and delicacy to the record. The following note, referring to the action of the apparatus previous to the year 1882, which has been inserted in the Introduction to the last published volume, that for 1886, may perhaps be with advantage repro-

duced here.—"Whilst the action of the pressure apparatus has been satisfactory for moderate winds, it is believed that the record of occasional very large pressures in years preceding 1882 was due principally to irregular action, in excessive gusts, of the connecting copper wire, but the brass chain being always in tension, the movements of the recording pencil have since been in complete sympathy with those of the pressure plate, and in this condition of the apparatus, that is since the year 1882, no pressure greater than about 30 lbs. (on the square foot) has been recorded."

The reduction of the photographic records of the barometer from 1874 to 1876, and of the dry and wet bulb thermometers from 1869 to 1876, are nearly complete, and the results will appear in the volume for 1887. It is proposed when this work is finished to take in hand the further discussion of some of our accumulated meteorological results.—*April 8th*, 1889.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.A.S., Astronomer Royal for Scotland.—The Meteorological Work of this Observatory during 1888 has consisted of :—

1. The computation of the monthly schedules of observations made twice daily at 55 of the stations of the Scottish Meteorological Society, the preparation of the mean results and comparison of them with the averages of the past 32 years, for the use of the Registrar-General of Births, Marriages and Deaths in Scotland, who has, as usual, printed them in his Monthly and Quarterly Reports.
2. Readings of the barometer and three differently placed thermometers, together with ordinary weather notes, have been made daily at 1 p.m.
3. Weekly readings have been made of the earth thermometers sunk in a bore-hole in the rock to the depths of 21 feet, 10 feet, 4 feet, and 2 feet respectively.
4. Papers have been prepared by Prof. C. Piazzi Smyth, late Astronomer Royal for Scotland, entitled "Mean Scottish Meteorology for the last 32 years," and "Eight Years' Observations of the New Earth Thermometers."

These papers have been printed by the Royal Society of Edinburgh, and are to be published in Vol. XXXV. Part 3, of their *Transactions*. The first-mentioned paper consists of 31 Tables of mean monthly and annual results of Scottish Meteorology, with 14 Plates of curves derived from the various tabular numbers, and a discussion of the old Tables originally published, for the years 1856-71, in Vol. XIII. of *Edinburgh Astronomical Observations*, and of certain new Tables now published for the first time.

The paper on the Earth Thermometers contains 4 Tables, with 3 supplementary Tables, and 4 Plates of Curves, and a discussion of the results.

There is also an unfinished paper on the individual meteorological characteristics of the several stations of the Scottish Meteorological Society, intended originally to accompany the above-mentioned paper on Mean Scottish Meteorology. The work was, however, found too extensive to be completed in the time available.—*January 25th*, 1889.

THE KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—G. M. Whipple, B.Sc., F.R.A.S., Superintendent.—The several self-recording instruments for the continuous registration respectively of atmospheric pressure, temperature, and humidity, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year. The standard eye observations for the control of the automatic records have been duly registered, together with the daily observations in connection with the U.S. Signal Service synchronous system.

The tabulation of the meteorological traces has been regularly carried on, and copies of these, as well as of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted to the Meteorological Office.

Owing to trouble caused by bursting of the water-reservoir for the thermograph wet-bulbs during frosty weather, and the risk of their imperfect action owing to

leakage of water, a double tank has been made, so that in the event of the inner vessel bursting, the outer one will prevent any loss of water.

The number of instruments under observation has been increased by the addition of a snow gauge on Prof. Nipher's principle for the purpose of measuring deep falls of snow, but no opportunity has occurred since its erection of testing its indications.

Seven months observations have been made of an 8-inch gauge, with the view of determining the effect of paint upon the inner surface of the collecting funnel.

During the period that the east room of the Observatory was undergoing alteration, the working standard barometer, Newman 34, was temporarily removed to a position a few yards distant in the North Hall. Comparisons were made with the Welsh standards, which were carefully cased in, during the time of occupation of the room by workmen, both before, subsequent to its removal, and after its replacement in its old position.

The electrograph under repair at time of last Report, owing to its partial destruction by fire, has been put in thorough order. The de la Rue battery, employed to charge it, has been cleaned, and its cells refilled by the makers. The scale-value of the instrument has been again determined by means of the portable electrometer (White's), and found to be practically unaffected by the accident.

The past year has been very unfavourable to cloud photography at the Observatory. The opportunities of taking negatives of cirrus, to which particular attention is directed, were rare in the earlier months of the summer, and during the later the building operations prevented, in a great measure, the work being carried on.

Several modifications have been introduced into the system of observing, materially simplifying it, and the mathematical treatment of the pictures has also been temporarily set aside in favour of mechanical methods, which affords results of a sufficiently close degree of accuracy in a small fraction of the time occupied by the other plans of reduction which have been employed hitherto.

Observations of cloud height, drift, and direction have been treated in this manner for 1887 and for 1888, generally with satisfactory results. During April special photographs were taken with one camera only, for showing the structural change in cirrus in short intervals of time, and seven sets of negatives were procured, exhibiting the extensive alteration sometimes observed in this class of cloud in from one to three minutes.

Since January 1888 tables of the monthly values of the rainfall and temperature have been prepared and sent to the Meteorological Sub-Committee of the Croydon Microscopical and Natural History Club for publication in their *Proceedings*. Detailed information of all thunderstorms observed in the neighbourhood during the year has also been regularly forwarded to the Royal Meteorological Society soon after their occurrence.

By permission of the Committee, Mr. Whipple has attended at Hersham on several occasions, and assisted Mr. W. H. Dines, B.A., F.R.Met.Soc., in the experiments in progress, on behalf of the Wind Force Committee of the Royal Meteorological Society, for determining the value of the Robinson constant for anemometers of various dimensions, and also for verifying the factor for converting wind velocity into pressure. The experiments are similar to those carried out at the Crystal Palace in 1874.

In the verification department about 1,500 instruments belonging to one or other of the twenty-seven different classes have undergone examination, and in the rating branch of the Observatory 639 watches have been submitted to the specified tests.—*January 22nd*, 1889.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, M.A., F.R.S., Radcliffe Observer.—The meteorological observations have been made on the same plan, and with the same instruments, with the addition of four new thermometers for comparison, as in the year 1887.

The instruments are in good order and working satisfactorily; readings of the standard instruments are frequently taken each day, and sometimes through the night, for check of the scale of the photographic sheets. The zero readings of the principal thermometers are generally independently determined each year,

and all the other thermometers in use are compared with them; the index-errors of some of these thermometers were also determined by Mr. Whipple on September 26th; the correction, when sensible, is always applied to every published reading.

The Daily and Weekly Weather Reports and the evening forecast published by the Meteorological Office, together with the readings of our instruments at 8 a.m., are exhibited at the outer gates of the Observatory, and attract considerable attention.

Weather Reports have been sent, as in previous years, daily (by telegram) to the Meteorological Office; bi-monthly to the United States Signal Office; monthly to the Registrar-General and local newspapers; and yearly to Symons's *British Rainfall;* and to others by request.

The amount of sunshine for 1888 was less than in any year since the recorder was mounted in 1880, and the amount of cloud was large, causing the year to be very unfavourable for astronomical observations. An unusually heavy fall of snow occurred on February 13th-14th, the depth in the Observatory grounds being between 20 ins. and 24 ins. On June 25th a severe thunderstorm accompanied by hail occurred, the hail-stones were unusually large, many fell in the grounds weighing between ¼ and ½ an ounce and one or two a little more; in the neighbourhood of Oxford, where the hail was heavier, many hundreds of windows were broken.

The months of July, August, and November of the year 1888 were of an abnormal character. During the months of July and August the registered hours of bright sunshine were respectively only 95 and 150. The mean temperature of July was 57°·5, which is 4°·1 below the average for the last 33 years, and that for August was 58°·4, or 2°·4 below the average: whilst the mean temperature for November was 46°·8, which exceeded the average by 4°·3.

The eye-observations are reduced to the end of 1888; the *Meteorological Results* for 1885 are now passing through the press. The photographic curves for 1887, and the anemograms for 1888, are under measurement; the rain-gauge curves are measured to the end of 1888, and the sunshine cards to date.—*February 4th*, 1889.

CAMBRIDGE OBSERVATORY.—Prof. J. C. Adams, F.R.S.—The meteorological work has been carried on by Mr. H. Todd. No change of instruments has been found necessary; but during the month of November the anemometer was discovered to be working badly, through the wearing of the spindle; it has since been repaired.

The weather throughout the year 1888 has been remarkable for the absence of genial spring or summer, the consequence has been there was no warmth, only on three days the temperature rose above 80°; June 25th it was 87°·5, August 9th and 10th 85°.—*January 9th*, 1889.

STONYHURST COLLEGE OBSERVATORY.—Rev. S. J. Perry, F.R.S.—During the past year the self-recording and other meteorological instruments have been kept assiduously at work; and besides the annual Observatory Report, weekly observations have been sent to the Meteorological Office, and monthly results forwarded to the same office and to the Registrar-General and the French Meteorological Society. Since November last a weekly report has appeared in the *Clitheroe Times*.

The upper glow is found to be less brilliant and less frequent than in preceding years. A large photo-spectroscope has lately been mounted at the Observatory, which may later be employed in certain meteorological researches.—*January 21st*, 1889.

REPORT ON THE HELM WIND INQUIRY.

By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary.

(Plate I.)

[Read February 20th, 1889.]

The subject of the Helm Wind has been brought before the Society on three previous occasions. On June 18th, 1884, a paper by the Rev. J. Brunskill on "The Helm Wind"[1] was read. This created a great deal of interest in the phenomenon, and subsequently the Council appointed a Committee to collect information on the subject. A report of this Committee "on the occurrences of the Helm Wind from 1871 to 1884"[2] was read on April 15th, 1885.

At the meeting on November 18th, 1885, I gave an account of the visit which I made to the district on August 19th to 21st, 1885, in company with Mr. T. G. Benn, F.R.Met.Soc.[3] We made the ascent of Cross Fell, drove through most of the villages between the mountain and the river Eden, and also went over Hartside Fell to Alston, on the eastern side of Cross Fell. By this means we gathered a great deal of general information, but nothing very precise as to what persons had *actually* seen or experienced. We came to the conclusion that if we were ever to get at the cause of the Helm Wind it would be necessary to have observations made on a systematic plan.

The contour of the country is as follows:—

The Cross Fell range of mountains forms part of the Pennine Chain, which runs from north-north-west to south-south-east. The range from Hartside Fell on the north to Hilbeck Fell on the south is high and continuous, and is not cut through by any valley. Behind this range on the east there is a high mass of land deeply cut by dales and valleys, but the tops of the mountains form a high table-land. Cross Fell is 2,900 feet, Dun Fell 2,780 feet, Dufton Fell 2,292 feet, and Hartside Fell 2,046 feet above sea-level. On the west there is the Vale of Eden, a plain some twenty miles broad, extending to the hills in the Lake district. From the top of the mountain to the plain on the west there is an abrupt fall of from 1,000 to 1,500 feet in about a mile and a half. At the southern end of the range the fall is but slight, there being a gradual fall of from 800 to 900 feet in five miles from Hilbeck to Winton.

Plate I. gives a reproduction of the Ordnance Survey Map (on a reduced scale) of this district.

At times when the wind is from some Easterly point, the Helm forms over this district; the chief features of the phenomenon being the following. A heavy bank of cloud rests along the Cross Fell range, at times reaching some

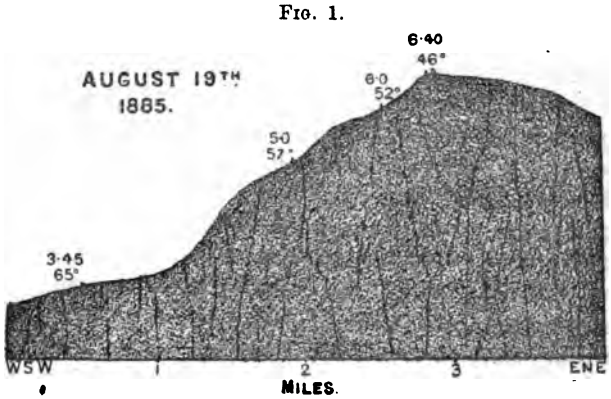
[1] *Quarterly Journal*, Vol. X. p. 267.
[2] *Quarterly Journal*, Vol. XI. p. 227.
[3] *Quarterly Journal*, Vol. XII. p. 1.

distance down the western slopes, and at others hovering just above the summit; while at a distance of three or four miles from the foot of the Fell a slender roll of dark cloud appears in mid-air and parallel with the Helm Cloud; this is the Helm Bar. The space between the Helm Cloud and the Bar is usually quite clear, while to the westward the sky is at times completely covered with cloud. The Bar does not appear to extend further west than about the river Eden. A cold wind rushes down the sides of the Fell and blows violently till it reaches a spot nearly underneath the Helm Bar, when it suddenly ceases.

On August 19th, 1885, Mr. Benn and I ascended Cross Fell in company with Mr. R. W. Crosby[1] and his nephew, and when descending in the evening we were so fortunate as to witness a slight Helm. We left Kirkland at 3.45 p.m., when the temperature of the air was 65°, the wind blowing lightly from the North-north-east. At 5 p.m. we were 1,950 feet above sea-level, the temperature being 57°, and the wind blowing steadily from North-north-east, force 4. By 6 p.m. we had reached 2,670 feet above sea-level, when the temperature was 52°. We gained the summit, 2,900 feet above sea-level, at 6.40 p.m., a few minutes before a mist came on and obscured the view on the east side of the Fell. The air was colder and damper, and the wind stronger; the temperature was 46°, and the wind North-north-east, force 5.

Fig. 1 gives a section of Cross Fell, with the temperatures observed during the ascent from Kirkland to the summit of the mountain.

FIG. 1.



SECTION OF CROSS FELL WITH TEMPERATURE OBSERVATIONS

Horizontal Scale about 1 inch to 7,000 ft. Vertical Scale about 1 inch to 2,000 ft.

The misty cloud soon covered the top of the Fell, and as we descended the wind increased in force till it reached force 6.

About 8 p.m. we saw the Helm Bar suspended in mid-air a little below our level, but away apparently over Melmerby, Ousby, Kirkland, Milburn, &c. The

[1] Since this Paper was read I have heard with much regret of the death of Mr. Crosby. He was a most careful observer, and rendered very great assistance in the Helm Wind inquiry.

Bar was really in two parts, there being a decided clear space between them. The northern portion of the Bar had a tendency to move southwards, while the southern portion had a tendency to move northwards. The middle of the Bar appeared to be nearly over Kirkland, while the northern extremity reached to about Renwick, and the southern extremity to Knock Pike. I have endeavoured in Fig. 2 to give a rough sketch of the Bar as seen from Cross Fell.

FIG. 2.

HELM BAR. AS SEEN FROM CROSS FELL AUGUST 19, 1885.

Although the Bar appeared to be nearly stationary it was quite evident that there was much commotion in the cloud itself, as portions of the upper and lower surfaces were whirled about in all sorts of ways. We saw this commotion to advantage, as the moon was nearly behind the cloud during the greater part of the time we were descending the mountain. Just before reaching Kirkland at 10.30 p.m. we became conscious that the wind had suddenly ceased and that the air was much warmer. This fact seemed so strange that Mr. Benn went back about fifty yards and there found the wind blowing quite strongly from the Fell, while where I was standing the air was calm or nearly so, with an occasional light puff of wind from the South-west. The Helm Bar was now nearly overhead. This showed that under the Bar there was an upward current.

Mr. Crosby, who left us at 7.15 p.m. to return to Kirkby Thore, while Mr. Benn and I proceeded northwards to Ardle Head Mine, observed the same peculiarities. The next day he sent me the following account:—

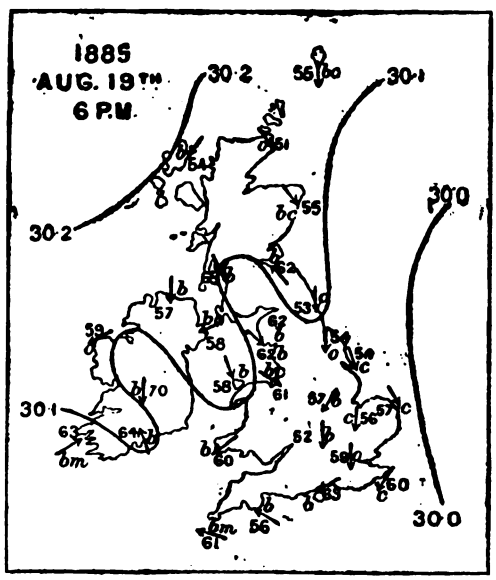
"In coming down the face of the ledge I noticed little scraps of vapour beginning to condense in the clear space South-west of us, and remarked to my companion that we should probably get out of the wind before we got home, as there was a very strong indication of the setting of the Helm Bar.

"We crossed the stream forming the County Boundary, about 300 yards above the fence wall of the Fell, and followed the track along the outgang towards Milburn. The condensing was still going on, and there was now a slender string of cloud standing over Milburn-town head;—the white mist was clinging close to the Fell tops, and all the other parts were clear, the slender Bar stretching from about Howgill Castle to Kirkland, at about the apparent level of the second ledge of Cross Fell, or that of the Silver Band Mine. About half way between the Fell foot and Milburn, say ¾ mile from the Bar, we suddenly became aware that we had lost the wind and it was dead calm,—so still that a lighted candle might easily have been carried bare. We searched our pockets for matches to test it, but unfortunately they were not there; however, though we did not actually prove it, we were both certain that it could have been done, and we had ocular demonstration a little later. We stopped and listened, and the peculiar sighing, murmuring sound of the Helm Wind could be distinctly heard, coming from the quarter where we parted with our friends. The sound was not loud,—the whole affair being of course on a much smaller scale than it often is; but the characteristics of the Helm Wind were plainly there. The air, which had

been very cold, was now warm and balmy as a summer evening, and before we got 200 yards from the place where we first noticed the calm we met several very light puffs of air from the South-west. We reached Milburn about 8.45 p.m., the Bar being directly overhead just before we entered the village. It was now dark except for the moon, and as we passed the School, one of a group of men sitting on the step struck a match to light his pipe, but hearing our footsteps he turned and had a good look at us, holding the pipe in one hand and the match in the other. After satisfying his curiosity he kindled his tobacco without losing his light, and so demonstrated the perfect stillness of the air at that point. We took the road by Milburn Mill and Hale Grange to Kirkby Thore; just after passing the Mill we had a steady breeze from South-west for about five minutes, force about 3; but on the whole it was calm all the way home, where we arrived at 9.45 p.m."

The Daily Weather Chart for 6 p.m. is represented in Fig. 8. From this it will be seen that the gradients were slight and that fine weather prevailed over the greater part of the British Isles; the only part covered with cloud being the North-east coast of England.

FIG. 8.



Weather Chart.

Having witnessed a slight Helm, we were enabled to request observations on certain definite features. Special forms were prepared and sent to a number of persons in the district who had promised to fill them up.

Observations and reports have been received from the following places:—

Alston (Love Lady Shield)	T. W. Dickinson
Appleby (Fair Hill)	W. Wallace
Ardle Head Mine	J. C. Russell
Askham	W. T. Nicholson

Blencowe	T. Fawcett
Cashwell Mine	A. Shield
Culgaith	Rev. G. W. Atkinson
Dufton	C. Liddle
Edenhall	B. W. Lovejoy
Kirkby Stephen	J. Rennison
Kirkby Thore	R. W. Crosby
Kirkland	Rev. A. Edwards
Langwathby	J. Powley
Lazonby	Rev. B. W. Wilson
Little Salkeld	W. Arthur
Melmerby	Rev. A. C. Pittar
Milburn	J. W. Harrison and D. Smith
Newton Reigny	T. G. Benn
Ousby	Miss Golding
Renwick	T. Savage
Skelton	T. Toppin
Temple Sowerby	J. Byres
Tynehead	T. Richardson

In order to discuss the observations I prepared some small charts comprising the northern part of England and the south of Scotland, and on these I plotted the direction and force of the wind, the temperature of the air, and the amount of cloud, at all the stations over the whole of that area which were available on each day when a Helm Wind was reported. It was at once seen that the Helm occurred mostly when the general direction of the wind was East or North-east, although it occasionally occurred when the wind was North or South-east.

In the accompanying Table I have given for each month of the three years 1885-87, the number of days (1) on which the wind over the greater part of the country blew from some Easterly point (that is from North to South-east); (2) when the local wind was from the Eastward (for this the observations at Newton Reigny have been used); (3) when there was a Helm formation; and (4) when there was a Helm Bar.

From this Table it will be seen that the Helm occurs at all seasons of the year; and that it is not such a rare occurrence as was generally supposed to be the case—the Helm Bar having been observed on 41 occasions in 1885, 68 in 1886, and 19 in 1887. In the Appendix I have given the observers' notes on several Helms, in order to show that the phenomenon is not restricted to any particular season.

As already stated, the wind blows strongly down the Fell sides until it comes nearly under the Bar; it then rushes upwards, and so produces a calm beneath the Bar. The air in rushing upwards draws the air inwards and upwards along with it on the other or western side. This accounts for the Westerly wind which blows on the western side of the Bar. Further to the westward, away from the influence of this eddy, there should be a *downward*

DAYS OF EASTERLY (NORTH TO SOUTH-EAST) AND HELM WINDS, 1885–1887.

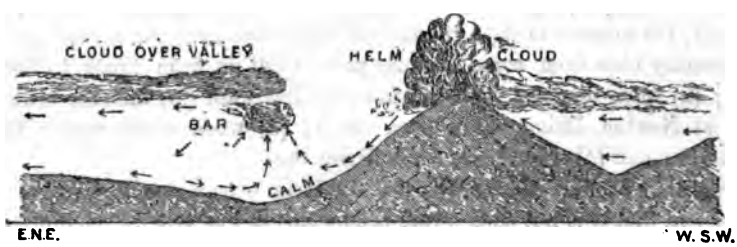
Months.	General East Wind.			Local East Wind.			Helm Formation.			Helm Bar.		
	1885.	1886.	1887.	1885.	1886.	1887.	1885.	1886.	1887.	1885.	1886.	1887.
January	14	11	6	19	10	10	12	8	0	8	8	0
February	2	10	8	12	14	12	2	12	5	0	9	2
March	8	16	6	16	18	8	12	16	1	1	13	0
April	15	17	11	20	18	13	11	11	9	5	9	4
May	7	15	16	13	16	19	5	12	12	0	4	8
June	6	5	9	11	12	10	2	6	2	2	3	0
July	7	3	1	10	6	2	1	1	2	1	1	0
August	14	3	4	20	7	4	9	3	2	7	0	0
September	1	10	5	9	12	7	0	6	4	0	3	1
October	9	19	4	12	21	7	12	15	4	9	5	2
November	12	4	10	18	12	18	9	7	7	7	3	2
December	3	4	6	5	7	7	2	5	4	1	5	0
Totals	98	117	86	165	153	117	77	102	52	41	63	19

current from the eastward. This has been confirmed by observations made by Mr. Dent, on April 21st, 1888. (See Appendix, p. 116.)

The ends of the Bar are frequently joined to the Helm cloud, so that the clear space between assumes an oval or an elliptical form.

Fig. 4 gives a section of the Cross Fell range and the Eden valley, and shows approximately the position of the Helm cloud and the Bar, with the direction of the wind.

FIG. 4.



Section of Cross Fell Range and the Eden Valley, showing approximately the position of Clouds and Wind Movement during the prevalence of the Helm Wind.

On examining the charts already referred to it was seen that whenever the Helm occurred the sky was almost invariably cloudy to the eastward; and probably the stratum of cloud was of no great altitude. The distribution of pressure was mostly of a cyclonic character.

The phenomenon appears to be due to the abrupt descent of the hills on the west, the air in pouring over the declivity is warmed in its descent and is consequently able to hold a greater amount of moisture in suspension.

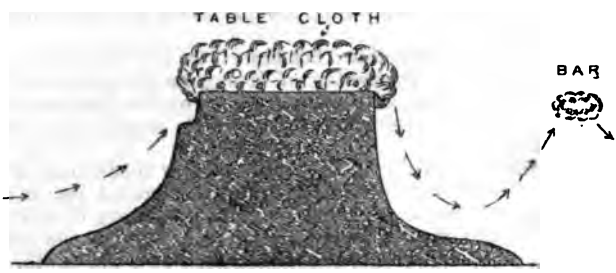
The cloud therefore is dissolved on the western side of the Fell, and only reforms at a distance of several miles after the disturbance caused by the irregularity in the contour of the land has been overcome. The Bar is produced by a rebound or ricochet of the air at the foot of the Fell, the Bar indicating the width of the upward current and also the point at which condensation takes place. The roaring sound which is heard when the Helm wind blows is no doubt due to the rush of cold air down the sides of the Fell.

Similar winds occur on Table Mountain, Cape Colony, and on the Hackgalla Mountain in Ceylon.

Sir John F. W. Herschel, in his *Meteorology*, pp. 95-97, gives the following account of the "Table-cloth":—

"That the mere self-expansion of the ascending air is sufficient to cause precipitation of some of its vapour, when abundant, is rendered matter of ocular demonstration in that very striking phenomenon so common at the Cape of Good Hope, where the South or South-easterly wind which sweeps over the Southern Ocean, impinging on the long range of rocks which terminate in the Table Mountain, is thrown up by them (as marked by the arrows in the direction of fig. 5), makes a clear sweep over the flat table land which forms the summit of

FIG. 5.



The "Table-Cloth" on Table Mountain. Rough schematic diagram with vertical distances purposely exaggerated, modified from Herschel's *Meteorology*.

that mountain (about 3,850 feet high), and then plunges down with the violence of a cataract, clinging close to the mural precipices that form a kind of background to Cape Town, which it fills with dust and uproar. A perfectly cloudless sky meanwhile prevails over the town, the sea, and the level country, but the mountain is covered with a dense white cloud reaching to no great height above its summit, and quite level, which, though evidently swept along by the wind, and hurried furiously over the edge of the precipice, dissolves and completely disappears on a definite level, suggesting the idea (whence it derives its name) of a 'table-cloth.'

"Occasionally, when the wind is very violent, a ripple is formed in the aerial current, which, by a sort of rebound in the hollow of the amphitheatre in which Cape Town stands, is again thrown up, just over the edge of the sea, vertically over the jetty, where we have stood for hours watching a small white patch of cloud in the zenith, a few acres in extent, in violent internal agitation (from the hurricane of wind blowing through it), yet immovable, as if fixed by some spell, the material ever changing, the form and aspect unvarying. The Table-cloth is formed also at the commencement of a 'North-wester,' but its fringes then descend on the opposite side of the mountain, which is no less precipitous."

Sir Samuel W. Baker in his *Eight Years in Ceylon* (pp. 145-148) gives the following account of a wind similar to the Helm Wind, but without the Bar, which occurs on the Hackgalla Mountain in Ceylon:—

"From June to November, the South-west Monsoon brings wind and mist across the Newera Ellia mountains. Clouds of white fog boil up from the Dimboola Valley, like the steam from a huge cauldron, and invade the Newera Ellia plain through the gaps in the mountains to the westward. The wind howls over the high ridges, cutting the jungle with its keen edge, so that it remains as stunted brushwood, and the opaque screen of driving fog and drizzling rain is so dense that one feels convinced there is no sun visible within at least 100 miles.

"There is a peculiar phenomenon, however, in this locality. When the weather described prevails at Newera Ellia, there is actually not one drop of rain within four miles of my house in the direction of Badulla. Dusty roads, a cloudless sky, and dazzling sunshine astonish the thoroughly soaked traveller, who rides out of the rain and mist into a genial climate as though he passed through a curtain. The wet weather terminates at a mountain called Hackgalla (or more properly Yakkadagalla, or Iron Rock). This bold rock, whose summit is about 6,500 feet above the sea, breasts the driving wind, and seems to command the storm. The rushing clouds halt in their mad course upon its crest and curl in sudden impotence around the craggy summits. The deep ravine formed by an opposite mountain is filled with the vanquished mist, which sinks powerless in its dark gorge; and the bright sun, shining from the east, spreads a perpetual rainbow upon the gauze-like cloud of fog which settles in the deep hollow.

"This is exceedingly beautiful. The perfect circle of the rainbow stands like a fairy spell in the giddy depth of the hollow, and seems to forbid the advance of the monsoon. All before is bright and cloudless, the panorama of the Ouva country spreads before the eye for many miles beneath the feet. All behind is dark and stormy; the wind is howling, the forests are groaning, the rain is pelting upon the hills.

"The change appears impossible; but there it is, ever the same; season after season, year after year, the rugged top of Hackgalla struggles with the storms, and ever victorious the cliffs smile in the sunshine on the Eastern side, the rainbow reappears with the monsoon, and its vivid circle remains like the guardian spirit of the valley.

"It is impossible to do justice to the extraordinary appearance of this scene by description. The panoramic view in itself is celebrated, but as the point in the road is reached where the termination of the monsoon dissolves the cloud and rain into a thin veil of mist, the panorama seen through the gauze-like atmosphere has the exact appearance of a dissolving view; the depth, height, and distance of every object, all great in reality, are magnified by the dim and unnatural appearance; and by a few steps onward the veil gradually fades away, and the distant prospect lies before the eye with a glassy clearness made doubly striking by the sudden contrast.

"The road winds along about midway up the mountain, bounded on the right by the towering cliffs and sloping forest of Hackgalla, and on the left by the almost precipitous descent of nearly 1,000 feet, the sides of which are clothed by alternate forest and waving grass. At the bottom flows a torrent, whose roar ascending from the hidden depth increases the gloomy mystery of the scene.

"On the North-east and South-east of Newera Ellia the sunshine is perpetual during the reign of the misty atmosphere, which the South-west monsoon drives upon the western side of the mountains. Thus there is always an escape open from the wet season at Newera Ellia by a short walk of three or four miles.

"A long line of dark cloud is then seen, terminated by a bright blue sky. So abrupt is the line, and the cessation of the rain, that it is difficult to imagine how the moisture is absorbed.

"This sudden termination of the cloud-capped mountain gives rise to a violent wind in the sunny valleys and bare hills beneath. The chilled air of Newera Ellia pours down into the sun-warmed atmosphere below, and creates a gale that sweeps across the grassy hill-tops with great force, giving the sturdy rhododendrons an inclination to the North-east, which clearly marks the steadiness of the monsoon."

I am indebted to Mr. R. H. Scott, F.R.S., for the translation of the subjoined notice of "An interesting Cloud Formation over the Bay of

Buccari," by Prof. H. Mohorovicic, which appeared in the *Meteorologische Zeitschrift* for February 1889, p. 56, and which bears upon the subject of the Helm Bar :—

"We do not often read of a whirlwind with its axis horizontal, and I have not been able to find any notice of such a phenomenon in the *Meteorologische Zeitschrift*. I think, therefore, that what I say may be of interest.

"The following are the observations taken at Buccari (lat. 45° 18′ N, long. 14° 33′ E) on October 17th, 18th, and 19th, 1888 :—

October, 1888.	Barometer.	Temperature.	Vapour Tension.	Relative Humidity.	Wind.		Amount of Cloud.	Motion of Clouds.	
					Direction.	Force.		Cirrus.	Cumulus.
	Ins.	°	In.	o/o					
17th, 7 a.m. ..	30·134	53·4	·236	58	E	3	0	....	Not measurable
10 a.m. ..	..	..	..	..	..	..	..	....	S 60° E
2 p.m. ..	·067	58·1	·209	43	E	4	2	....	Not measurable
4 p.m. ..	..	..	..	..	..	..	..	S 60° E	S 75° E
9 p.m. ..	30·020	53·1	·232	57	E	6	2	....	E
18th, 7 a.m. ..	29·914	53·8	·232	56	N	3	7	S 15° E	N 50° E
10 a.m. ..	..	..	..	..	..	..	..	S 5° E	N 85° E
11 a.m. ..	·926	..	..	..	..	..	8	....	....
2 p.m. ..	·882	56·7	·209	45	SE	6	9	Not measurable	N 70° E
4 p.m. ..	·867	..	..	..	..	..	8	S 35° W	S 80° W
9 p.m. ..	29·969	55·6	·228	51	E	6	1	....	Not measurable
19th, 7 a.m. ..	30·083	44·2	·130	45	E	2	0	....	N 45° E
2 p.m. ..	30·138	49·1	·134	39	E	3	0	....	NNE

"On October 18th at 10 a.m. the drift of the upper strato-cumulus was N 45°E, and of the lower N 80°E ; about 4 p.m. the drift of the strato-cumulus was N 65°E.

"Early in the morning on October 18th the sky was densely overcast and the barometer falling. On the mountains to the North-east we saw a long row of cumulus stretching from North-west to South-east, with its summits torn into a fringe. From these masses of scud of various sizes broke off, and they constantly diminished in bulk as they approached the zenith. Not one of these reached the altitude of 50°, and a strongly-marked descending motion was observable in them. In the South-west there was a similar mass of cumulus, as far as could be seen. It was parallel to that previously noticed, and it extended from the altitude of 70° to 20°, so that the zenith was quite clear of cumulus, and over the hills of Kostrena we could see in parts blue sky and in parts the upper clouds. Above the cumulus two layers of small strato-cumulus were visible, which distinguished themselves from each other by differences in their motion. Through the interspaces of the strato-cumulus some long streaks of cirrus running North and South appeared ; these moved to the Southward.

"Over the middle of the Bay of Buccari small patches of cloud were forming themselves throughout the day, and had no horizontal movement at first, but when they grew bigger and began to ascend, they moved quickly to the North-east and East, at a rate I estimated at 15 or 16 metres per second, and they disappeared in the main mass of the cumulus. Just over Kostrena similar cloud patches could be seen, growing smaller and smaller and at last vanishing. The main mass of the cumulus showed no progressive motion.

"Early in the morning the wind was North, force 3. Afterwards it came from all directions, at times North-west, South-west, South-east, and North-east. Towards noon the axis of the cumulus shifted towards South, and it broke up into separate fragments. In the afternoon it became compact again. Below Kostrena, in the Gulf of Fiume, the wind blew in frightful squalls from West and North-west. In the harbour of Portorè there were violent squalls from all directions. The local steamer which plies between Fiume and Buccari had some heavy sacks

actually blown off her deck. It is impossible to imagine the existence of such a permanent mass of cumulus unless on the assumption of a rotatory motion about a horizontal axis. (The author illustrates this by a diagram which shows a marked ascending movement over Buccari as evidenced by the constant fresh formation of cumulus, and the influx of air from all sides).

"Above a horizontal motion from South-west, and at noon from West, appears and over the Gulf of Fiume there was a descending and returning motion, as proved by the loose fragments of cumulus and by the wind. It is probable there was a similar mass of cumulus over the mountains to the North-east. The phenomenon lasted till 5 p.m.

"The same phenomena were observed on the afternoon of the 17th, but not so distinctly. Such circulations are not rare here, and are probably due to the formation of the ground, which is in terraces. When there is a Bora, which there was on the days in question, there is usually a long bank of cumulus in the North-east, from which particles break loose but never reach the zenith, over Buccari. In the South-west they reappear and vanish on the horizon. This shows a descending followed by an ascending motion."

Dr. Hann appends a note pointing out the analogy between the phenomena described in the paper, and the Table-cloth at the Cape, and the Helm Wind.

APPENDIX.

Extracts from the Observers' Notes on several Helm Winds.

NOVEMBER 19TH, 1885.

ARDLE HEAD, OUSBY, Mr. J. C. RUSSELL. 3.30 p.m. Helm Cloud about 300 feet below the summit of Cross Fell. The Bar apparently over and parallel to the Eden, the north end being somewhere about Croglin and the south end about Stainmore in Westmoreland. Both ends of the Bar are joined to the Helm Cloud. The wind is East. Clouds and vapour near the Bar move about as though in a whirlwind. Thaw set in, with some very fine snow falling. Very strong wind up here on the fell, but hardly any wind down in the valley. The Helm only lasted about 22 hours; it began about 5 p.m. on Wednesday.

OUSBY RECTORY, Miss GOLDING. 3 p.m. The Helm Cloud covering the top of Cross Fell, and extending the whole length of the Fell as far as can be seen. No Bar to be seen, but a mass of heavy clouds all round the horizon without a break, joining the Helm Cloud on each side at the north and south ends, and apparently reaching on the west about halfway between Penrith and Ullswater. The direction of the wind is East. A few higher clouds are slightly whirling in and out, but not moving in any particular direction. The belt of clouds seemed to have a centre a little to the north of the top of the Fell, and the wind seemed to push the clouds north and south from that centre, and to chase them all round till they met in the west, where they made a bank a little higher than the Ullswater Fells. Cross Fell was a little hazy.

MELMERBY RECTORY, Rev. A. C. PITTAR. 10.45 a.m. The top of Cross Fell is hidden. The Bar consists of fragmentary light clouds to the west. The north end of the Bar is rather close, apparently not much further than Gamblesby; the south end is a good distance off, probably at Appleby. The north end of the Bar is very distinctly joined to the Helm Cloud, and the south end seems to be. The direction of the wind is South-east. The weather cold, dry and windy, with blue sky.

3 p.m. The Bar seemed a long distance off to the west, and joined all round with the Helm Cloud. There was not much wind, and towards evening the Helm Cloud began to sink behind the Fells. There was a quiet night and but little of the Helm visible next morning, and no Bar.

The Helm Cloud appeared yesterday afternoon. The wind blew at times keenly in the night; blowing this morning in strong gusts. The Bar at the

north end is well defined, but does not seem to extend far, and ends in fragmentary clouds which continue across the western sky in the direction of the south end.

LITTLE SALKELD, Mr. W. ARTHUR. Midday. Helm Cloud covering Cross Fell. No Bar. Wind East.

LANGWATHBY, Mr. J. POWLEY. 9.30 a.m. Helm Cloud on the top of Cross Fell; mountain slope clear. No Bar. Wind East. Clouds rising in front of Helm.

TEMPLE SOWERBY, Mr. J. BYRES. 9 a.m. Helm Cloud along the top of Cross Fell and quite down the mountain: very dense. No Bar. Wind East. Slight clouds coming out of the Helm.

Helm wind came on during the night; strong constant East wind all day; no Bar, but at times broken clouds coming from the east. The cloud over the mountain one dense mass at 3 p.m., more into cumulus over Dun Fell. Towards evening very cloudy.

MILBURN, Mr. J. W. HARRISON. 6 p.m. Helm Cloud just covering the summit. The Bar is about on a line with the Eden; the north end might be about as far as Lazonby and the south end about Brough. The Bar is joined at both ends with the Helm Cloud. The wind is North-north-east.

When I left home for the mine after dinner all was clear overhead and very fine, with dark cloud on the other (west) side of the country. Before I got to the mine thin fleecy clouds began to gather on the top of the Fell, and sharp puffs of wind, almost like whirlwinds, began to blow, and soon the Helm formed.

MILBURN, Mr. D. SMITH. 10.30 a.m. Helm Cloud extending from 600 ft. below the summit of Cross Fell to 200 ft. above. The Bar lying apparently from south-east to west of north. The north end of the Bar over Morland, and the south reaching south of Dufton. The south end of the Bar is joined to the Helm apparently at Dufton. Wind East. Small cloudlets breaking off from the Helm and moving eastward. Much agitation on the south-east of the Bar, clouds breaking off and moving north-west. Intensely cold and dry.

2 p.m. Wind changing fitfully and blowing from the South-east. Fleecy clouds covering the west and north. Weather becoming milder; and a little rain.

KIRKBY THORE, Mr. R. W. CROSBY. 9 a.m. Dense Helm on Cross Fell. Wind East-north-east.

Helm set on Fell at 4 p.m. yesterday (18th). Bar broken, and general North-east wind.

APPLEBY, FAIR HILL, Mr. W. WALLACE. About 7.30 a.m. I observed the Helm wind blowing from the Fell towards Appleby with great velocity. The sky over the vale of the Eden to the west was, in a great measure, clear, and there was no cloud Bar formed in connection with the wind. I observed that when the Helm clouds reached Appleby they were checked in their course to the west, by nothing visible, and portions of the swiftly moving clouds were thrown back to the east for a short distance. There were three strata of scattered small clouds to the east. The cirrus seemed quite still; at least I could detect no motion. I however detected a very slight motion to the east in the middle stratum. In about an hour and a half the whole of the sky in the upper part of the Eden was clouded over; the sky, however, in the lower part continued tolerably clear until about noon.

At 1.30 p.m. the appearance of the Helm Cloud was truly magnificent. The whole of the vale of the Eden was clouded over, but the sun shone brightly on the Helm Cloud, which was far above the top of Cross Fell. There was great disturbance where the Helm Cloud and Bar joined at the north end of Cross Fell, and the resplendent clouds rapidly changed their forms into fantastic shapes. The Bar drifted in the direction of the wind, and small dark clouds rose out of the Helm, and moved in almost every direction except to the East and in the direction of the wind. As soon as these small dark clouds approached the Bar they turned from it and fell back towards the Helm Cloud; but in every case that came under my observation they faded away and became invisible before reaching the Helm Cloud.

FEBRUARY 18TH AND 19TH, 1886.

MELMERBY, Rev. A. C. PITTAR. 18th, 5 p.m. Bar to the westward, the north end being about Unthank, and the south end a little beyond Ousby. The north and south ends of the Bar are joined to the Helm Cloud. Wind East, moderately strong.

LITTLE SALKELD, Mr. W. ARTHUR. Helm on three days. Cloud high above Cross Fell. Bar close; about 2 miles from the bottom of the Fell. We had no wind here, and never have when the Bar is close to us at Little Salkeld. Wind North-east.

KIRKLAND, Rev. A. EDWARDS. 19th, 9 a.m. Fells hidden. Wind East, light. Frost and snow. Temperature 30°·5.

KIRKBY THORE, Mr. R. W. CROSBY. 18th, 9 a.m. Helm with broken Bar. Wind East-north-east, overcast. Temperature 36°·2.

19th, 9 a.m. Helm with Bar close to the Fell. Wind South-east, overcast, with snow showers. Temperature 31°·8.

MAY 13TH, 1886.

CASHWELL MINE, Mr. A. SHIELD. 9 a.m. Wind North-east. Temperature 37°.

LANGWATHBY, Mr. J. POWLEY. 10. a.m. Helm Cloud on the top of Cross Fell, and not far down. Bar to the eastward of this place, and pretty close to the Fell; the north end is about Gamblesby, and the south about Appleby. Bar at the north end joined to Helm Cloud. Wind North-east. Bar joined by black cloud to west, and stretching from Lazonby to about Appleby. Bitterly cold; snow on the hills.

1 p.m. Mountain nearly clear, Helm breaking off. Bar disappearing. Wind East, but not so strong; no roaring sound.

On the day before (12th) Cross Fell was quite invisible, but the mighty roar of the wind was very distinctly heard.

KIRKLAND, Rev. A. EDWARDS. 9 a.m. Helm Wind. Overcast; rain, hail, and snow. Severe storm. Temperature 40°.

KIRKBY THORE, Mr. R. W. CROSBY. 7 p.m. Helm Cloud covering the high points of Cross Fell, and reaching nearly down to the first ledge from the top. The Bar is to the eastward of this place; the north end stretches as far as can be seen, and the south end is over the Stainmore depression. The south end of the Bar is joined to a continuation of the Helm Cloud on the Cross Fell range. Wind West-north-west, force 5. Bar Cloud is moving from the North-east, force 6. High clouds between the Helm and the Bar apparently stationary, with perhaps a slight drift from North-north-west. Ragged clouds on the eastern edge of the Bar ascending and condensing. Temperature 41°.

There has been more or less Helm since Sunday (9th), but the wind was strongest yesterday (12th), and through last night; about noon to-day it moderated and turned warmer; but is rising again this evening and turning cold.

LANGRIGG, NEAR MUSGRAVE, Mr. J. RENNISON. 6.20 p.m. Helm on north fells; much broken south of Roman Fell; but wind roaring about Hilbeck. The Bar seemed to be 1 or 2 miles from the fells, until it got opposite to Roman Fell, when it turned west over Crosby Garrett. It then swept round by Kirkby Stephen and South Stainmore; a stream of clouds connecting it with the Helm Cloud at Windermere end. Though not under the Bar the wind was quite calm, except gusts from both East and West. The Helm Cloud along Warcop and Hilbeck Fells drifted north to Roman Fell, when a stream of clouds blew across towards the Bar but wasted away before they got to it.

I heard from some shepherds that the wind was very strong on the Fell. One young man said it took him completely off his feet, and that he came down on his back. Others said that they could scarcely stand at all.

MAY 28TH, 1887.

KIRKBY THORE.—Mr. W. R. CROSBY says:—There was a splendid specimen of the Helm Wind this morning. On looking out a little before 6 a.m., I found that the whole of the range of hills visible from our house was closely covered with a thick fleecy sheet of cloud, which fitted the ground so exactly that one

could see the shape of the prominent parts reproduced on the upper surface of the cloud, although it must have been some hundreds of feet thick at the summit.

This cloud was driving rapidly down the slope, the surface having a sort of billowy appearance but retaining its consistency until it reached the Fell foot, where it seemed to break up like spray at the foot of a waterfall, and then disappear ; there was a great quantity of this spray-like vapour in some places,—notably on both sides of Knock Pike, for some distance along the Fell foot.

Murton Pike was enclosed in the cloud,—Dufton and Knock Pikes stood out but there was a thick cap on the top of Dufton Pike, retaining the shape of the Pike on its upper surface. I was reminded of the description given by Mr. Wallace and printed by the Royal Meteorological Society in their report.[1] On close observation one could see that immense masses of vapour were being driven rapidly down Dufton Gill, and, striking against the almost perpendicular eastern face of the Pike, were projected high into the air, until bent over by the upper current, when they fell downwards over the top of the Pike, and melted away about a quarter of the way down the Pike side. Looking towards the East or East-south-east, the rolling billowy masses of vapour showed very distinctly, and had a most magnificent appearance, lit up with the bright morning sun.

The Bar was formed of a dense roll of cloud, at a low elevation, and stood a little west of the River Eden. It joined the Helm Cloud at both ends, and thus an almost clear space of blue sky was surrounded by dense masses of vapour. The form of this space was a tolerably regular ellipse, extending, roughly speaking, from Brough to Langwathby, the ends being rounded by the connection between the Helm Cloud and the Bar. Looking South-west directly at the Bar (distant then short of half a mile) both ends appeared to be drifting towards the centre, or rather, towards a point straight opposite to where I stood. I believe, however, that this was merely an optical deception, caused by the laws of perspective, by which the vapour drifting South-westwards in parallel lines appeared to converge towards the point of sight. On going to a place directly under the Bar I found the vapour overhead driving straight towards South-west, streaming out of the clear air from North-east, and condensing as it approached the thick part of the Bar, just in the same way as is usual when the Bar stands nearer the Fell, and the endwise motion could not be discerned from that standpoint.

There were no scraps of cloud driving across between the Helm Cloud and Bar, all the lower air being quite clear and bright between, from the place where the spray-like vapour disappeared to that where the condensation began. There was, however, a light fleecy cloud about the centre of the ellipse at a considerably higher elevation than the Helm Cloud, which had a gentle motion from East-north-east, with whirling eddies ; this cloud, though in constant motion, retained its position in the same way as the Bar does, the waste on the South-west being constantly replenished from North-east.

The wind at our house was blowing strongly from a little East of North-east, a moderate gale somewhat gusty and irregular in force. The movement of the vapours on the Fell side showed that there a furious blast was raging.

Wishing to observe the condition of things under the Bar, I walked toward the South-west, to a point about 200 yards beyond the River Eden. Every step westward found the wind decreasing in force, until about half-way, there began to be slight puffs in a contrary direction : the smoke of a chimney by the main road side was blown from North-west, but the currents at that point were unsteady. I got under the North-east edge of the Bar a little before reaching the Eden, and found that it was gradually advancing towards the Fell. Standing on the wooden bridge across the Eden, I found a steady breeze from North-west blowing up the river. I went about 200 yards further, and met a steady gentle breeze from the West,—the usual feature of a Helm with a regular Bar, but which I was anxious to test when the Bar stood far away from the Fell, as in this instance. I stayed here a few minutes to make observations ; the whole sky westward was obscured with clouds, of which the Bar formed the eastern edge ; overhead the cloud, which was low, was so dense and compact that its motion could not be

[1] *Quarterly Journal*, Vol. XI. p. 233.

discerned, although the rapid drift at the edge showed that a strong current was passing overhead. The loud roaring of the wind on the Fell could be distinctly heard, resembling the sound of a heavy train on the railway,—indeed, but for its continuity, a stranger to the Helm would have judged the sound to be that of a train. On returning homewards I found that, as the sun got higher, the Bar was advancing towards the Fell, and growing less dense. I had the wind from the West at my back all the way home, but on reaching the house met again the North-east current, much decreased in force since I went away, the North-east edge of the Bar being now nearly over the house,—this would be about 7 a.m.

On making the usual observations at 9 a.m., I found the Bar closed up to about half-way between Kirkby Hove and the Fell; the clouds overhead were much thinner, and their speed decreased to that of a moderate breeze, the direction being still from East-north-east. The ground wind was now a light breeze from the South. As the day advanced the dense vapours of the Bar were dispersed, and broken into fragments of cirrus cloud, at a higher level; the wind lessened in force, and the Helm Cloud drew back towards the Fell top, leaving the principal part of the slopes clear of vapour.

APRIL 21ST, 1888.

KIRKBY THORE. Mr. R. W. CROSBY. 9 a.m. Strong Helm. Fell tops thick. Overcast. Surface wind West-south-west, force 2. Upper wind North-east, force 5. Temperature 40°.

Mr. W. Dent, of Street House, told me that as he left home about 9 a.m. for Appleby market, the wind at that point was furious from North-east, and seemed to *fall down* upon him. When he got to Bolton, about a mile nearer the Fell, he found the wind was gently blowing in the opposite direction, as it was at Kirkby Thore. This settles a point I have long suspected but never proved before, viz. that the current comes down again after its bounce up at the Bar. Street House is about a mile and a half south-south-west from Kirkby Thore.

DISCUSSION.

The PRESIDENT (Dr. Marcet) said that with reference to the phenomena of the Helm Wind the main question to be considered was their cause. Probably the air on the western slope of Cross Fell was warmer than that on the eastern slope, and the cold and heavier air of an Easterly wind dropped down the western slope, the excess of its moisture being absorbed in the warmer air on that side. The air on the western side of the hill was warmer, apparently because of its being heated by terrestrial radiation to a greater degree than the air on the eastern slope.

Mr. BAYARD inquired whether the Bar ever rose above the level of the bottom of the Helm Cloud, and also if the Helm Cloud and Bar only occurred in the afternoon.

Mr. TRIPP suggested that the cloud formation on Table Mountain might be partly due to the meeting of two opposing air currents at the summit. He was induced to think so because of some observations quoted by Mr. J. G. Gamble in a paper on the rainfall of the Cape of Good Hope. At the Katberg, on the spurs of the watershed of which Table Mountain forms the southern extremity, these showed that on the coast side of the watershed constant summer rains prevailed coming from the south-east, while on the northern or inland side thunderstorms were simultaneously experienced, these apparently coming from the north-west. The peculiarity with regard to Table Mountain was the great drop in elevation, no such sudden change of level occurring in the northern portion of the watershed.

Mr. LAWSON said he had frequently seen the Table-cloth on Table Mountain. Sir John Herschel's diagram gave an imperfect idea of the configuration of the mountain, which, with an ascending ridge of several miles in length on the south, terminated in an abrupt precipice on the north, 3,600 feet above the sea and 2½ miles from the margin of Table Bay. The precipitous face extends downwards about 1,000 feet, and from its base the ground falls to the margin of Table Bay, at first somewhat abruptly, but afterwards more gradually over the site of Cape Town. The Table-cloth always occurs with a South-easterly wind, and com-

mences to form on the weather side of the mountain ; it flows over the crest, and descends rapidly, the cloud dissolving completely as it falls. Up to 1 p.m. the heat of the sun usually causes an inflow of air from the portion of Table Bay under the lee of the mountain ; this extends over the town, and must be compensated by a return current of equal amount over it, but while these lasted the town and the bay for a mile and a half northwards were unaffected by the South-easter ; about 1 p.m., however, it set in suddenly, and blew a hard gale over the whole space previously exempted. When the Table-cloth appears the South-east wind prevails extensively over the surrounding sea, the weather is usually clear and bright, and there is no indication of an opposing current except the local one just mentioned. Though he had witnessed the phenomenon many times, Mr. Lawson never remarked the bar of cloud mentioned by Sir John Herschel, but this may have arisen from his observations being made in Cape Town itself, while Sir John's were made at a point several miles to the eastward, beyond the influence of Table Mountain, which afforded him a side view which would have rendered a thin film of condensed vapour visible, which, seen from beneath, might have escaped observation. A similar phenomenon to the Table-cloth is seen at Gibraltar when a damp Easterly wind is blowing.

Mr. STRACHAN inquired whether the cloud formed at any particular time of the day, and what evidence there was of the existence of an upward current under the Bar and a downward current further westward. Could not arrangements be made for temperature observations to be made on both the eastern and western slopes of Cross Fell ?

Mr. SYMONS said that although he had often been over this district he had never had the good fortune to witness an occurrence of the Helm wind. From the accounts of the tremendous force exerted by this wind he expected to find great evidence of its destructive effects, but he was surprised to find no signs of such destruction to trees, hayricks, &c. as he had been led to expect. One circumstance which doubtless played a part in the production of the Helm wind, was that to the east of Cross Fell a series of valleys ran from 2,000 ft. down to sea-level, and these formed channels by means of which the air was conducted to the summit, carried over it, and then it fell down the west side. There was evidence of an upward current under the Bar, but observations with small captive balloons or kites were needed to satisfactorily determine it.

Mr. C. HARDING said it was curious that there should be so large a difference between the number of occurrences of Helm formations in 1887 compared with former years. It was perhaps due to unfavourable conditions, and he was rather inclined to think this was the case. It would be interesting to trace the connection of this phenomenon with cyclonic and anticyclonic conditions. He believed that the Helm wind was more common in cyclonic than anticyclonic weather. He should like to know whether a fall of temperature took place on the summit before the formation of the cloud. He could not understand why there should be a downward current, nor why it should be of such strength. The Bar was spoken of as forming over a certain district, but he hardly thought it was stationary, and he should like to know whether it was really so. He believed the whole phenomenon was due to a process of suction, in the same way that a current of air passing over a basin causes suction.

Mr. HARRIES remarked that with the exception of the formation of the Bar above the leeward base of the hill there was practically no difference between the Helm wind of Cumberland and the Föhn wind of the Swiss and New Zealand Alps, the Rockies, and other very high mountain ranges. He had never heard of the Bar being observed in connection with the descent of the air from these great elevations, and he was therefore disposed to explain the phenomenon by purely local considerations—the comparatively short distance of the descent from the summit having only a limited influence in modifying the capacity of the atmosphere for moisture, and the contour of the ground at the base acting as a check to the advance of the mountain wind and at the same time favouring a current in an opposite direction, we have the intervening calm and the ascent of the warm air. The condensation of the slight amount of moisture still retained by the Helm wind forms the small cloud, or Bar, shown on the diagrams.

Mr. SOUTHALL remarked that the district over which the wind blew before reaching Cross Fell was of sufficient extent to reduce the temperature.

Mr. MARRIOTT said that the extracts from the observers' notes given in the

Appendix gave full information on several points raised in the discussion. The Helm wind was not confined to any particular time of the day, but seemed to blow at all hours. The Bar was not always formed over the same spot, and was not stationary; it varied in position from near the Fell-foot to as far west as over the river Eden. With regard to the small cloud or Bar referred to by Sir J. Herschel as forming sometimes over the jetty at Cape Town when the "Table-cloth" was on Table Mountain, he (Mr. Marriott) had communicated with Mr. E. J. Stone, F.R.S. (H.M. Astronomer at the Cape of Good Hope Observatory 1870-79) on the subject, who had replied as follows:—"During my residence at the Cape 1870-1879, I frequently saw the reflexed formed cloud described by Sir J. Herschel in the extract which you have forwarded. I considered then, and I still consider, Sir John Herschel's description of, and explanation of the causes of, the cloud satisfactory; and I have nothing of importance to add to his account of the phenomenon."

RAINFALL AT CORELLA, NEW SOUTH WALES, 1879-1888.

By the Ven. ARCHDEACON WYNNE, M.A., F.R.Met.Soc.

[Received January 2nd.—Read February 20th, 1889.]

The Royal Meteorological Society not having up to this time published any account of the rainfall of recent years in the colony of New South Wales, I beg to offer the following monthly returns furnished to me by a relative who occupies a large sheep farm, where 70,000 sheep depend on the rainfall, and consequent river supply, for means of subsistence.

In the years 1888 and 1884 extreme distress was experienced for want of water, and many of the most prosperous settlers were ruined. The past year (1888) was even worse. The total rainfall was only 7·68 inches, and the prospects of the country for the summer were alarming.

Rainfall at Corella, near Bourke, New South Wales, Lat. 30° S, Long. 146° 15′ E, in the Years 1879–1888. Height above Sea-level 400 feet.

Month.	1879.			1880.			1881.			1882.			1883.		
	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.
	In.		In.	In.		In.	In.		In.	In.		In.	In.		In.
January	..	..	..	·70	2	·50	1·99	3	1·01	·33	4	·25	..	..	..
February	1·70	4	1·20	8·84	8	4·25	1·14	8	·46	8·41	8	4·24	1·66	4	1·42
March ..	1·50	2	1·00	·95	2	·70	1·96	7	1·00	·44	2	·36	·94	3	·60
April	1·50	2	1·25	3·17	6	·82	..	..	..	2·75	3	1·37	1·69	3	1·18
May	2·36	6	1·23	·15	1	·15	1·76	7	·93	1·76	4	1·23	2·47	6	·92
June	·89	2	·70	..	..	..	·42	4	·33	1·54	8	·52	·11	1	·11
July	1·75	2	1·00	·07	2	·04	·02	1	·02	·15	1	·15	..	..	..
August ..	2·24	5	?	·08	1	·08	·31	4	·18	·31	3	·15	·60	4	·33
September	1·82	3	1·12	2·39	3	1·45	1·09	3	·94	·18	2	·10	..	..	..
October ..	1·57	4	·62	·54	3	·21	1·29	4	·81	1·68	6	·50	2·94	6	1·63
November	·85	2	·45	..	..	..	5·78	6	1·70	3·50	7	·65	·95	4	·77
December	·12	1	·12	·08	1	·08	·16	3	·08	1·01	4	·76	·15	1	·15
Total ..	16·30	33	..	16·97	29	..	15·92	50	..	22·06	52	..	11·51	32	..

RAINFALL AT CORELLA, NEAR BOURKE, NEW SOUTH WALES, LAT. 30° S, LONG. 146° 15′ E, IN THE YEARS 1879–1888. HEIGHT ABOVE SEA-LEVEL 400 FEET—*Continued.*

Month.	1884.			1885.			1886.			1887.			1888.		
	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.	Total Fall.	No. of Days.	Max. Fall.
	In.		In.	In.		In.	In.		In.	In.		In.	In.		In.
January	..	..	..	4·89	9	1·91	·34	3	·18	2·92	5	1·75	1·75	5	·92
February	·56	2	·43	·98	2	·58	·11	1	·11	1·87	7	·89	2·80	10	1·15
March ..	..	..	..	2·50	6	·66	..	..	..	7·14	10	2·79	·18	1	·18
April	1·04	2	1·00	1·57	3	1·01	·12	3	·5	..	..	..	..	..	..
May	·17	3	·09	1·39	3	·71	·73	7	·36	·27	3	·24	1·76	2	·93
June	2·23	3	1·07	1·35	6	·50	1·93	4	1·07	1·36	6	·70	·14	2	·09
July	·95	5	·47	..	..	..	5·30	8	1·50	1·47	7	·81	..	..	..
August ..	·75	1	·75	·10	1	·10	2·80	11	·95	4·38	8	1·87	·03	1	·03
September	·88	4	·40	·72	5	·26	·41	6	·15	·03	1	·03	·88	2	·74
October ..	·75	1	·75	·32	1	·32	2·78	10	·90	·75	6	·31	·07	2	·04
November[1]	1·04	2	·58	1·14	4	1·02	3·38	5	1·21	2·31	4	1·45	·02	1	..
December	1·29	2	·94	1·41	7	·74	1·48	6	·67	4·50	8	2·78	..	..	..
Total ..	9·66	25	..	16·37	47	..	19·38	64	..	27·00	65	..	7·63	26	..

[1] The figures for November and December 1888 and the comparative table have been added since the Paper was read.

For purposes of rainfall comparison I add the following table of rainfall means and extremes at nine selected Stations in New South Wales. The means are for 10 to 12 years.

Station.	Lat. S.	Long. E.	Mean Fall.	Highest.		Lowest.	
				Amount.	Year.	Amount.	Year.
	° ′	° ′	In.	In.		In.	
Goonoo (Hill Station)	31·20	150·34	25·40	39·7	1887	15·4	1880
Inverell (Do.)	29·48	151·10	29·71	47·6	1879	20·5	1881
Fort Bourke (Plains)	30·5	145·52	14·99	24·14	1887	8·9	1884
Kinchega (Central Plain)	32·30	142·25	10·20	18·38	1887	5·88	1883
Lalaltee (Plains)	35·38	145·49	19·48	30·38	1875	13·9	1877
Milton (Coast SE)	35·14	150·20	47·06	71·23	1887	..	..
Mulwala (Murray R.)	35·59	146·3	20·13	32·0	1887	13·32	1884
Yancannia (Swampy Plains)	30·12	142·50	12·33	17·97	1877	5·6	1884
Corella (Plain)	29·32	146·15	16·28	27·0	1887	7·63	1888

DISCUSSION.

Mr. TRIPP said that he had recently been examining the rainfall in various parts of the world, and he had noticed that both in Australia and New Zealand, and at the Cape of Good Hope, the rainfall appeared to have been gradually decreasing for some years past, perhaps since 1872, while at Buenos Ayres, in the Argentine Republic, it had been increasing.

Mr. SYMONS remarked that the change referred to by Mr. Tripp was probably only of a temporary character.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

JANUARY 16TH, 1889.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

MAXWELL HALL, M.A., F.R.A.S., Montego Bay, Jamaica;
GEORGE THOMAS LIVESEY, M.Inst.C.E., Camden Park, Tunbridge Wells;
CHARLES WILLIAM PRIESTLAY, B.Sc., F.G.S., Avonbrook, Tewkesbury;
JOSEPH RADCLIFFE, Todmorden Water Works, Todmorden; and
Rev. JOHN REMINGTON STRATTEN, 9 Park Square, Leeds,
were balloted for and duly elected Fellows of the Society.

JANUARY 16TH, 1889.

Annual General Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

Mr. H. HARRIES and Mr. W. B. TRIPP were appointed Scrutineers of the Ballot for Officers and Council.

Dr. TRIPE read the Report of the Council and the Balance Sheet for the past year. (p. 72.)

It was proposed by the PRESIDENT, seconded by Dr. TRIPE, and resolved:—
"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal* of the Society."

It was proposed by Mr. ELLIS, seconded by Mr. BREWIN, and resolved:—
"That the best thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

It was proposed by Mr. LAUGHTON, seconded by Capt. CABORNE, and resolved:—
"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by Mr. BAYARD, seconded by Col. BROOKE, and resolved:—
"That the thanks of the Society be given to the Standing Committees, and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

The PRESIDENT then delivered an Address on "Fogs." (p. 59.)

It was proposed by Mr. SCOTT, seconded by Mr. SYMONS, and resolved:—
"That the thanks of the Society be given to the President for the ability and courtesy displayed by him in the Chair during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal* of the Society."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year, viz.:—

President.

WILLIAM MARCET, M.D., F.R.S., F.C.S.

Vice-Presidents.

FRANCIS CAMPBELL BAYARD, LL.M.
HENRY FRANCIS BLANFORD, F.R.S., F.G.S.
WILLIAM ELLIS, F.R.A.S.
RICHARD INWARDS, F.R.A.S.

Treasurer.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

Trustees.

HON. FRANCIS ALBERT ROLLO RUSSELL, M.A.
STEPHEN WILLIAM SILVER, F.R.G.S.

Secretaries.

GEORGE JAMES SYMONS, F.R.S.
JOHN WILLIAM TRIPE, M.D., M.R.C.P.

Foreign Secretary.

ROBERT HENRY SCOTT, M.A., F.R.S., F.G.S.

Council.

EDMUND DOUGLAS ARCHIBALD, M.A.
WILLIAM MORRIS BEAUFORT, F.R.A.S., F.R.G.S.
ARTHUR BREWIN.
GEORGE CHATTERTON, M.A., M.Inst.C.E.
WILLIAM HENRY DINES, B.A.
FREDERIC BERNARD EDMONDS.
CHARLES HARDING.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
CAPT. JOHN PEARSE MACLEAR, R.N.
EDWARD MAWLEY, F.R.H.S.
HENRY SOUTHALL.
CHARLES THEODORE WILLIAMS, M.D., M.A., F.R.C.P.

FEBRUARY 20TH, 1889.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

HENRY DROOP RICHMOND, F.C.S., Thornton Lodge, Stonebridge Park, Willesden ; and
FRANCIS GRAY SMART, M.A., M.B., F.L.S., Bredbury, Tunbridge Wells, were balloted for and duly elected Fellows of the Society.

The following Papers were read :—

"REPORT ON THE HELM WIND INQUIRY." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 103.)

"AN ATMOSPHERIC SKETCH." By F. A. VELSCHOW, F.R.Met.Soc.

"RAINFALL AT CORELLA, NEW SOUTH WALES, 1879-88." By the VEN. ARCHDEACON WYNNE, F.R.Met.Soc. (p. 118.)

CORRESPONDENCE AND NOTES.

A Design for obtaining an Automatic Record of the Light transmitted from each Quarter of the Atmosphere.

To William Marriott, Esq., F.R.Met.Soc.

Dear Sir,

In your paper on "The Application of Photography to Meteorology,"[1] you give me credit for having first suggested it in 1838, when I sent a paper on the subject with results to the Royal Cornwall Polytechnic Society. At that date there were difficulties in the way, tending to hinder progress in the general application of the system, which have long been removed by more recent discoveries in Photography and far more perfect means of obtaining papers which yield uniform results. When each observer had to prepare his own paper, and the chloride of silver was the only agent in use, it was scarcely possible that different observers should produce comparable results. But now that good and suitable paper is manufactured for the use of engineers, which can be depended on for the purpose, there is no reason why the records of different stations should not be fully utilised.

By your interesting paper I learn that "No instrument has yet been devised to record automatically the amount of cloud;" and it is this fact which induces me to call your attention to an instrument which I have recently designed, that I believe would give a useful approximate result. What I have endeavoured to accomplish is, to obtain a numerical record of the light transmitted from the zenith, and from each quarter of the atmosphere, at an angle of 60° from the horizon, for every hour during an entire week, without change of paper or personal observation, the result being given in percentages of full sunshine.

The examples of such records, sent herewith for your inspection, will serve to illustrate my meaning. They are obtained with a rudely-constructed experimental instrument, made for the purpose of testing the principle of action.

Externally the instrument will have much the appearance of an old-fashioned eight-day clock, with a dial-plate divided for 24 hours, and one hand revolving in that time; the hour spaces may be divided to ten minutes, the only object of the dial being to show at a glance that the time is being correctly kept.

The regulator of the clock movement is a well-compensated seconds pendulum, and its work is to revolve two metal cylinders or drums carrying bands of sensitised paper at any desired rate, say one inch per hour, in which case the circumference of the drums must be 24 inches.

One of these drums I prefer to place in the plane of the meridian, and the other at right angles to it; with the exception of the small apertures in the scales hereafter described, the whole of this apparatus is in the clock-case, which is a perfectly dark chamber.

The meridian drum carries a strip of paper 4½ or 5 inches wide, on which three records are registered.

The centre record gives the zenith light, embracing 30° on each side of it, the one above it on this paper the north light from 60° to the horizon, and the lower one will in like manner give the south light. In azimuth the acting light on these scales will be that from 90° of the atmosphere; all other light being shaded off the scales. The east and west drum carries a strip of paper 3 inches wide which receives two records, being respectively the east and west light from similar angles.

To avoid a lengthened description of the scales, I enclose, with the records, that used in the experimental instrument. It is far from being perfect, but will serve to illustrate what is intended. To form these scales properly I should begi n by ascertaining the time required for full sunshine to produce a well-defined line on the paper to be used, and also the time of exposure required to give a similar line during a fog or from a very dark cloud, and I should make the length of their terminal apertures equal to the length of paper which would pass them in the same time and the intermediate one as nearly as possible in geometrical progression.

[1] *The Journal of the Camera Club*, Vol. III. No. 28, p. 32.

Should you think such an instrument of any value as a light measurer or worthy of employment at meteorological stations, I shall feel obliged by any criticisms you may be pleased to make.

Yours truly,

THOS. B. JORDAN.

"Winnipeg," Cherry Orchard, Staines.
March 20th, 1889.

RAIN FROM A CLOUDLESS SKY ("SEREIN") AT STEVENAGE, JULY 22ND, 1888. By SAMUEL JONES. (Extract from a letter to Mr. J. Bailey Denton.)

"I beg to submit to your notice certain phenomena observed by me at Stevenage, on Sunday, July 22nd, 1888, about an hour and a half before the approach of a violent thunderstorm. I was standing in the court-yard of my dwelling and talking with a friend who was a farmer; the weather being then a rather ticklish question with him. I observed what appeared to be the commencement of a shower, and I asked him if it did not rain, to which he said 'No.' We continued the conversation for about the space of five minutes, when he suddenly broke it off by ejaculating 'It does rain.' I said 'How can that be when there are no clouds?' I knew the appearance was of an unusual character, and my question and answer were directed with the view of leaving him an unconscious witness of the cause of it, so that he might give his testimony unbiassed by anything I might have said.

"The appearance was first seen about 7 p.m., and it looked like a shower of luminous particles of a somewhat skim-milky appearance. As soon as I realised the fact of its electrical nature I endeavoured to ascertain if the movement of the particles was upwards or downwards, but without effect. But what I did more successfully observe was that the particles were of the size of tare-seed, and that they moved in remarkably straight lines, so much so that they resembled the warp in a weaver's frame. My view extended over about two-fifths of the circle of the heavens, and the appearance within that area was precisely the same. My observation lasted a quarter of an hour. The sky was cloudless but hazy looking to the North-west. The subsequent storm came in that direction, being very severe at Sandy."

NOTE ON THE FREQUENCY OF LONDON FOG. By ALEXANDER B. MACDOWALL.

THE phenomenon of fog has been studied a good deal of late; but apparently little attention has been given as yet to the matter here proposed, viz. the comparative amount of fog (in London) in recent successive years, and in the winter months, regarded separately.

In the daily remarks on weather at Greenwich, as given in the *Registrar-General's Weekly Return*, may be found a means of measurement (no doubt rough) of this frequency. I have lately gone through these records for the periods November to March (inclusive) in the 31 years 1858-1888: the method being to count the number of days on which the word "fog" or "foggy" occur in the reports. No notice is taken of the distinction "slight fog" or "dense fog"; the mere fact of "fog" being considered. Neither "mist" nor "haze" is taken into account.

Adding together the number of days on which fog was thus observed in each winter season, we get a series of figures roughly measuring the fogginess. The yearly average for the whole series is about 26 days; or about 5 days in each of the 5 months considered.

The monthly totals are given in the accompanying Table.

The most foggy winter in this series seems to have been 1879 (*i.e.* 1879-80); and the least foggy 1876. Relative maxima also occurred in 1867, 1872, 1886, and relative minima in 1863, 1868, 1884 and 1887.

I am unable to throw any light on the cause of those fluctuations.

We might be inclined to think that the most foggy winters would coincide

with the most severe winters, but this apparently does not always hold good: 1872 was a very foggy winter, but not very severe.

With regard to distribution of fogs in the months, a recent writer in *Nature*, Mr. Raffles, from daily fog observations on Primrose Hill in 1887-88, found January the most foggy month. This is no doubt sometimes the case; but taking the average of those 31 years we get a different result. Adding the fog days in each month, we get November 221, December 219, January 163, February 105, March 108; or, on an average, November 7·1, December 7·0, January 5·3, February 3·4, March 3·5.

While November and December are thus shown to be pre-eminently the foggy months, and to nearly the same extent, we may remark that each of the five months has at different times presented a maximum of fog-days in the season; even March in one instance, the winter 1886-7.

NUMBER OF DAYS ON WHICH FOG WAS REPORTED AT GREENWICH, 1858-1888.

Year.	Nov.	Dec.	Jan.	Feb.	Mar.	Total.
1858	9	4	4	2	2	21
1859	10	3	4	1	1	19
1860	6	8	10	0	0	24
1861	5	8	3	4	4	24
1862	12	1	1	5	4	23
1863	3	1	9	2	2	17
1864	11	9	4	2	1	27
1865	7	9	1	4	3	24
1866	8	8	7	3	2	28
1867	16	9	0	2	2	29
1868	4	4	3	1	4	16
1869	8	3	5	1	3	20
1870	14	6	2	3	6	31
1871	10	13	3	3	3	32
1872	4	12	1	10	9	36
1873	5	12	1	6	6	30
1874	14	8	1	5	1	29
1875	2	11	9	3	1	26
1876	7	1	6	0	0	14
1877	3	3	4	7	5	22
1878	7	10	6	2	6	31
1879	10	17	9	4	3	43
1880	6	3	10	5	4	28
1881	3	7	11	8	7	36
1882	4	9	3	4	2	22
1883	7	8	6	3	3	27
1884	6	0	7	0	4	17
1885	5	11	5	6	5	32
1886	8	6	9	8	10	41
1887	5	5	7	1	2	20
1888	2	10	12	0	3	27
Average	7·1	7·0	5·3	3·4	3·5	26·3

RECENT PUBLICATIONS.

AMERICAN METEOROLOGICAL JOURNAL. A Monthly Review of Meteorology, Medical Climatology and Geography. Vol. V. Nos. 9-11. January-March 1889. 8vo.

The chief articles are:—The organisation of the Meteorological Service in some of the principal countries of Europe, by A. L. Rotch (28 pp.). In these Nos. the author gives an account of the service in France.—Increase of Rainfall,

by F. Waldo (7 pp.).—Note on the influence of Forests upon Rainfall, by W. Ferrel (2 pp.).—The Exhibition of the New England Meteorological Society (6 pp.). Following the custom of the Royal Meteorological Society, this Society held a very successful exhibition of meteorological instruments in connection with its meeting in January. This paper describes the various instruments exhibited.—West Indian Hurricanes and the March Blizzard (20 pp.). This is an abstract of a lecture by Ensign E. Hayden, U.S.N.—State Tornado Charts, by Lieut. J. P. Finley (17 pp.). It is contemplated to publish a series of over 30 State tornado charts. In these Nos. the author gives the charts for Wisconsin and Georgia.—Anemometer Comparisons, by H. A. Hazen (8 pp.).

ANNUAIRE DE LA SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE. Tome XXXVI. September-October 1888. 4to.

Contains :—Memoire sur la thermodynamique de l'atmosphère, par W. de Bezold (10 pp.).—Crues de l'Oued M'Zab, depuis 1728 (2 pp.).

INDIAN METEOROLOGICAL MEMOIRS: being occasional Discussions and compilations of Meteorological Data relating to India and the Neighbouring Countries. Published under the direction of HENRY F. BLANFORD, F.R.S., Meteorological Reporter. Vol. IV. Part V. 1888. 4to.

Contains :—The Cyclone of May 25th to June 2nd, 1881, in the Arabian Sea, by F. Chambers (100 pp. and 14 plates). The author first gives a general description of the meteorology of the Arabian Sea and that part of the Indian Ocean which lies to the north of the Tropic of Capricorn. He shows that almost all the tropical cyclones of these seas originate in the equatorial belt of low atmospheric pressure. After discussing the results of this violent cyclone, the author brings out the fact that at a constant distance from the centre of the cyclone, the incurvature of the winds on different sides varied in a systematic way from nothing to four points of the compass. He also infers that the direction of motion of cyclones in the Arabian Sea in May and June is about six points to the left of the direction towards which the normal monsoon wind blows.

JOURNAL OF THE SCOTTISH METEOROLOGICAL SOCIETY. Third Series, No. V. 1889. 4to.

Among other information this contains the following articles :—St. Elmo's Fire on Ben Nevis, by A. Rankin (10 pp.). The most frequent manner in which St. Elmo's Fire makes its appearance at the Observatory is as caps of light on the tips of the lightning rod, but occasionally it appears as jets of flame projecting from all objects on the top of the tower, and from the cowl of the kitchen chimney, which rises from the roof at some distance from the tower. These jets are at times from 4 to 6 inches in length, and make a peculiar hissing sound. During a very brilliant display, the observer's hair, hat, pencil, &c. are aglow with the 'Fire'; but, except for a slight tingling sensation in the head and hands, he suffers no inconvenience from it. On such occasions, if a stick be raised above the head, jets of electric light will be seen on its upper end. The only drawback to observing it with advantage is the unpleasant character of the weather in which it appears, namely, blinding showers of snow and hail, and squally winds, causing a good deal of snowdrift. Up to the present time only 15 cases have been recorded at the Observatory; these occurred all in the night-time, and all during the winter months, beginning with September and ending with February. As far as local observation goes, St. Elmo's Fire is seen on an average 6 hours after the lowest reading of the barometer has been recorded, in a depression that occurs in a general low pressure area; it is preceded, accompanied, and followed by a falling temperature; before it is seen the wind has veered considerably, and goes on veering for some time after its appearance; and it is attended by heavy precipitation in the form of snow-hail.—The Climate of the Isle of Man, by A. W. Moore (17 pp.). This is a discussion of all the temperature and rainfall observations which have been made in the Isle of Man from 1830 to 1887.—Some rough Observations made in the interior of North Queensland, by Dr. J. Beddoe, F.R.S. (3 pp.).—Notice of a peculiarly effectual Hygrometer fifty years ago, by C. Piazzi Smyth (2 pp.).

METEOROLOGISCHE ZEITSCHRIFT. Herausgegeben von der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. HANN und Dr. W. KÖPPEN. January-March 1889. 4to.

The principal articles are :—Die Regenverhältnisse Indiens, von Dr. W. J. van Bebber (17 pp.). This is an analysis of Mr. Blanford's paper on the Rainfall of India, in the *Indian Meteorological Memoirs*.—Ueber den mittleren täglichen Gang des Barometers an heiteren und trüben Tagen zu Hamburg, von K. Nakamura (6 pp.). The author, who is a Japanese, endeavours to explain the diurnal oscillation of the barometer by the superposition of two oscillations, one of diurnal, the other of semi-diurnal period. The former stands in direct relation to insolation, while the latter does not. The editors remark that these results confirm those arrived at by von Lamont, and also by Mr. Rundell (*Quarterly Journal*, Vol. V. p. 36).—Interessante Wolkenbildung über der Bucht von Buccari, von Prof. H. Mohorovicic (3 pp. and plate). A translation of this paper is given in Mr. Marriott's "Report on the Helm Wind Inquiry" (see p. 111).—Beobachtungen über die Polarisation des Himmelslichtes insbesondere zur Zeit der Abenddämmerung, von F. Busch (14 pp.). This is an investigation into the conditions of polarisation in the atmosphere and the way in which its plane changes. The effect of the Krakatoa glows on this polarisation is also noticed.—Resultate der meteorologischen Beobachtungen der französischen Polar-Expedition 1882-83 am Cap Horn ; angezeigt von J. Hann (15 pp.). This is a very careful analysis of these observations. The reviewer remarks that there are numerous typographical errors in the tables.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. Vol. XXIV. Nos. 277-279. February-April 1889. 8vo.

The principal articles are :—Three days on the top of Mont Blanc (2 pp.).—The Old Barometer in Salisbury Cathedral (1 p.).—A Cold Period (3 pp.).—The Floods of March 8th-9th, 1889 (5 pp.).—Ground Ice, or Anchor Ice (6 pp.).—The Rainfall of Heligoland, by Dr. G. Hellman (2 pp.).

Quarterly Journal

OF THE

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EDITED BY A

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Royal Meteorological Society.

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Office:—30 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1889-90.

ORDINARY MEETINGS at 7 p.m.

Wednesday,	November	20, 1889.
,,	December	18, ,,
,,	January	15, 1890.
,,	February	19, ,,
,,	March	19, ,,
,,	April	16, ,,
,,	May	21, ,,
,,	June	18, ,,

ANNUAL GENERAL MEETING.

Wednesday, January ..... 15, 1890.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

NOTICE.

The Library and Offices of the Society are open daily from 10 a.m. to 5 p.m.; Saturdays, 10 a.m. to 2 p.m.

The Society is not responsible for the views and opinions advanced in the *Quarterly Journal*.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XV. JULY 1889. No. 71.

THE SUN, ITS HEAT AND LIGHT.

An Address delivered to the Royal Meteorological Society, March 20th, 1889.

BY DR. W. MARCET, F.R.S., PRESIDENT.

ON January 16th last I had the honour of addressing you on the subject of fogs, an appropriate one at the time, considering the state of the weather in the preceding month of December.

It so happens that the month of May, towards which we are rapidly drifting, is the sunniest in the year, hence little apology need be offered for drawing your attention this evening to the sun's heat and light.

An extract from J. B. Waring's book on *Ceramic Art in Remote Ages* shows the amount of awe and reverence with which, at one time, the sun was regarded:—"When the phenomena of life first led men to reflect upon the origin of themselves and of the vast world of nature which surrounded them, they could not be otherwise than struck by the fact of there being two sources of life, 1st, the reproductive animal principle, and 2nd, the vivifying power of the sun, which by means of its heat and light was

clearly not only the immediate parent or nurse of all inanimate existence, but might also be regarded as the source of all human and animal life as well, so powerful are its effects and so necessary its presence for the origin, continuance and progress of all life. Thus we find the early nations of all parts of the world claiming a solar origin and calling themselves children of the sun. The symbol of this great luminary—that of a circle—in various forms and arrangements, we shall find was in use among all nations of antiquity, and the very earliest form of it we meet with, that of a circle and central point, is still the solar emblem amongst astronomers."

The source or origin of all meteorological phenomena is the sun, which sends or radiates its heat through space to the earth. We can judge what the absence of the direct influence of the sun would be from the state of the polar regions throughout a long season of darkness and intense cold. Vegetation would become totally extinct, and human existence could not possibly be maintained. As it is, the sun apparently moving from south to north, and *vice versâ*, distributes its favours in turn throughout the globe, while the greater heat of the sun's rays between the tropics produces a central belt of marked meteorological phenomena from which they extend far and wide. The sun's influence diminishing as its rays fall more obliquely on the earth, the heat is transmitted through our atmosphere, whose temperature it raises but very slightly, though losing its own power in no inconsiderable degree.

If there were no air and moisture round the earth, we should feel the sun's heat to a much greater extent. After the rays have reached the earth a portion of the heat is absorbed by the earth and terrestrial objects, another is converted into motion, and a third portion is reflected into space.

The difficulty of determining the amount of solar heat the earth actually receives at the sea-level, by observing the amount which falls at a given time over a given space, is so great, that, according to Langley, the most competent observers differ by nearly a third of the whole amount in question.[1] Even the variations in the power of the atmosphere to transmit heat on clear days are great and surprising. Mr. Langley remarks:—"We are as though at the bottom of a turbid and agitated sea, and trying thence to obtain an idea of what goes on in the upper region of light and calm."

The agent which interferes most with the passage of the sun's heat through the atmosphere is aqueous vapour. Prof. Soret,[2] of Geneva, concludes that in winter, when the air is dry, the radiation (or passage of the sun's heat through the air) is more intense than in summer, and that in general, other things being equal, we obtain a higher degree of solar radiation when the air is dry than when it is humid, even though to the eye it may appear more transparent in the latter case.

It is perhaps thought at first sight that the solar heat is best measured in the same way as we are in the habit of employing for the temperature of the

[1] Langley, *Researches on Solar Heat.*

[2] *Association française pour l'avancement des Sciences. Congrès de Bordeaux.* 12535.

atmosphere, that is, by means of the thermometer; but bright mercurial thermometer bulbs reflect the sun's heat instead of absorbing it, and therefore thermometers give readings greatly below the truth, while thermometer bulbs blackened with lamp black, although absorbing the sun's heat, would give it out irregularly to the surrounding atmosphere by conduction, undergoing a process of cooling, just as the hand feels cold when in contact with a piece of iron.

The unsuitability of ordinary thermometers for the determination of the sun's heat led to the contrivance of the instrument known as the Actinometer, from *actin*, ray, and *metron*, a measure. Herschel's actinometer consists of a cylinder filled with a blue solution of copper ammonia-sulphate; this cylinder may be looked upon as the bulb of a very large thermometer, as it is soldered at one end to a graduated thermometer tube, into which the liquid rises when expanded by the sun's rays. The instrument is exposed several times for one minute in the sun and in the shade alternately, and in each case the changes of volume are read off on the scale. As stated by Herschel, the result obtained shows, by calculation, that the sun gives out an amount of heat sufficient to melt in one minute one-millionth part of a metre of a sheet of ice, if it fell vertically upon it. There are other instruments constructed with a similar object, such as the Pyrheliometer of Pouillet and the Actinometer of Violle; but that which is certainly the simplest, and is now, I may say, nearly exclusively in use, is the black bulb thermometer *in vacuo*. The principle of this instrument is the absorption of solar heat by a thermometer having its bulb and a small portion of the tube blackened, and thus prevented from reflecting any of the sun's rays; while it is enclosed in a glass case or jacket in which as good a vacuum as possible has been made. The object of the vacuum round the thermometer is to prevent loss of heat of the black bulb by convection to the air, with which under ordinary circumstances it is in direct contact. Such instruments can record two phenomena—the temperature of the air, and the intensity of the sun's rays—therefore in order to obtain the heat of the sun's rays only, it has been suggested to use two thermometers, both in vacuum jackets and alike in all respects except that one has its bulb and part of the stem blackened, while the other is left bright. Both instruments being exposed to the sun, the excess of the readings of the black bulb over those of the bright bulb thermometer will yield the amount of solar radiation. It is, of course, assumed that the bright bulb is not heated by the sun; indeed, such appears to be the case, as a mirror exposed to the sun's rays does not convey to the touch any sensation of warmth. The black-bulb thermometer is attributed in this country to Herschel, though the French claim Arago as its discoverer. Amongst the results of observations made with the black bulb thermometer *in vacuo*, I may record the remarkable fact that at *Davos*, the Swiss winter health resort, 5,000 feet above the sea, with the country under a deep coating of snow, the direct heat of the sun is actually greater than on the sunny shores of the Riviera at the same period of the year.

There is, however, a drawback to the present method of determining solar

radiation, from the circumstance that no two of these instruments, similarly exposed to the sun, read exactly alike. The Rev. F. W. Stow has introduced a great though simple improvement in the construction of these thermometers by extending the blackening of the bulb some little distance up the stem. This gentleman, who has given much attention to solar radiation, has, I understand, kindly brought for exhibition this evening an improved form of actinometer.

It will be seen in what follows that the temperature of the solar rays falls rapidly when tested at increasing altitudes in a balloon. This is not, however, always the rule when ascending above the earth's level on high mountains. On such occasions meteorological conditions are met with unknown in mid-air, such as the absorption of heat by the rocks or ground, the reflection of the sun's heat on snow, the local effects of certain warm or cold winds, &c. The height of the snow-line, or line of perpetual snow, is a good indication of the power of the sun in mountain districts, and we find it varying from the sea-level in the polar circle to an altitude of about 16,000 feet under the equator. Above the snow-line the heat of the sun is disposed of in two ways,—a portion of this heat is absorbed by the snow if below the freezing point, or it is used for melting it if above the freezing temperature; but by far the greatest amount is reflected from the snow. The excessive heat and light of the sun experienced in mountainous regions when walking over snow is well known to Alpine climbers, as it may be productive of serious effects upon health. Thus it is that unless due precaution be taken, an affection of the eyes is not uncommon, known as "snow-blindness," and requiring for its cure a prolonged stay in absolute darkness; blue or tinted spectacles should therefore be worn when on snow in the high Alps. It is also a frequent occurrence at such places as Zermatt or Chamounix, to see tourists appear at table d'hôte with their noses and lips swollen to twice their natural size, and their cheeks and ears also swollen and exhibiting scars as if the skin had actually been burnt.[1]

The temperature of the air, to those ascending in a balloon, exhibits, however, a distinct and considerable fall. Mr. Glaisher, in his memorable balloon ascent from Wolverhampton on September 5th, 1862, kept a record of temperatures showing the gradual cooling of the atmosphere at increasing altitudes above the earth. A short account of this remarkable ascent, from Mr. Glaisher's book, *Travels in the Air*, may perhaps not be out of place on the present occasion. Mr. Glaisher remarks: "We left the earth at 1.8 p.m., temperature of the air 59°, dew point 50°; the air was first misty; at the height of 5,000 feet the temperature was 41°, dew point 37°·9. At 1.18 we entered a dense cloud, when the temperature fell to 36°·5, dew point the same, indicating a saturation of moisture. At this elevation the report of a gun was heard; the clouds now became lighter, and on emerging from them at 17 minutes past 1, a flood of strong light burst upon us in a beautiful

[1] This, however, can be easily prevented by smearing the face with grease; oxide of zinc ointment, from its white colour, being perhaps one of the best preservatives.

blue sky, while beneath us lay a magnificent sea of clouds, its surface varied with endless hills, hillocks, and mountain chains, and with many snow-white tufts rising from it. . . . . We reached the height of two miles at 1.22 p.m., when the sky was of darker blue, and the earth was visible in occasional patches beneath the clouds; the temperature had fallen to the freezing point, and the dew point to 26°. The height of three miles was attained at 1.28 p.m., with a temperature of 18°, and dew point 13°. At 1.34 p.m. Mr. Coxwell was panting for breath. We reached the elevation of four miles (the height of Chimborazo) at 1.40 p.m., the temperature was 8°, the dew point −15°, or 47° below the freezing point of water. Discharging sand, we in ten minutes attained the altitude of five miles (26,400 feet), and the temperature had passed below zero and then read −2°. At this point no dew was observed on Regnault's hygrometer when cooled down to −30°. Up to this time," remarks Mr. Glaisher, "I had taken observations with comfort, and experienced no difficulty of breathing, while Mr. Coxwell, from his exertions, had breathed with difficulty for some time. Having discharged sand we ascended still higher, and I also found a difficulty in seeing clearly. At 1.51 p.m. the barometer read 10·8 inches. At 1.52 p.m., or later, I read the dry bulb thermometer at −5°; after this I could not see the column of mercury in the wet bulb thermometer, nor the hands of the watch, nor the fine divisions on any instrument. In consequence of the rotatory motion of the balloon, the valve line had become entangled, and Mr. Coxwell had to leave the car and mount into the ring to re-adjust it. I then looked at the barometer, and found its reading to be 9¾ inches, still decreasing fast, implying a height exceeding 29,000 feet. Shortly after," adds Mr. Glaisher, "I laid my arm upon the table possessed of its full vigour, but on being desirous to use it I found it powerless, and trying to use the other arm I found it powerless also. Getting my head upright for an instant only, it fell on my right shoulder; then I fell backwards, my back resting against the side of the car, and my head on its edge; in this position my eyes were directed to Mr. Coxwell in the ring. . . . : In an instant intense darkness overcame me, but I was still conscious with a perfectly active brain. . . . . Next I suddenly became unconscious, as in going to sleep. . . . . After a time the instruments became dimly visible, then Mr. Coxwell, and very shortly I saw clearly. Next I arose from my seat, and looked around as though awaking from sleep, though not refreshed, and said to Mr. Coxwell, "I have been insensible." He said, "You have, and I too, very nearly." . . . . Mr. Coxwell told me that he had lost the use of his hands, which were black from the cold, and I poured brandy over them. He also said that as he felt insensibility coming over him too, he became anxious to open the valve, but in consequence of having lost the use of his hands, he could not do this; ultimately he succeeded by seizing the cord with his teeth, and dipping his head two or three times until the balloon took a decided turn downward."

On recovering consciousness, Mr. Glaisher resumed his observations, at 2.7 p.m., the barometer reading 11·53 inches, temperature −2°.

In this ascent, on passing out of the clouds there was an increase of temperature of 9°, and then there was no interruption in the fall of temperature till the height of 15,000 feet was reached. At that elevation a warm current of air was entered which continued to 24,000 feet, after which the regular decrease of temperature was resumed up to the highest point reached. On descending, the same warmer current was again experienced between 22,000 feet and 17,000 feet, the evidence of its presence lasting until the balloon had descended to about the same height at which the current was entered on ascending; after this no further break occurred in the regular increase of temperature, the sky being clear till the descent was completed. From the general results with Regnault's hygrometer there can be no doubt that at heights exceeding 30,000 feet the air was very dry.

This account is very interesting as showing how little the atmosphere absorbs heat, and how great is the power of the earth to warm objects in its immediate vicinity or in contact with it.

This brings us to the subject of terrestrial radiation. The earth radiates, or gives out into space, the heat it receives from the sun; in the day-time an equilibrium or balance is obtained between the absorption and radiation of solar heat, and it is this equilibrium of temperature which is shown by the readings of the black bulb thermometer *in vacuo*. After sunset, the earth acquiring no further heat to make up for that it gives out, undergoes rapid cooling, and the temperature of the air in contact with it is also reduced. But you will ask, what becomes of the heat the earth is thus giving out after sunset and at night? This heat rises through the air until it comes into contact with moisture, and there it is first of all arrested, and next converted into the motion required to expand the moisture and increase its vapour tension. Hence it is that at sunset and for some time later the air is found to be warmer at a certain height above the ground than it is on the earth's surface. This phenomenon was clearly observed by Mr. Glaisher, up to an altitude of 1,900 feet, in his balloon ascent from the Woolwich Arsenal on October 2nd, 1865.

The radiation of terrestrial heat into space after dark is clearly concerned in the fact that nights are, as a rule, so much finer than days. The clearer nights are due to a combination of circumstances, the principal of these being, first, the increased temperature at night in the higher atmosphere; and secondly, the diminished evaporation from the soil due to the absence of the sun's heat.

A great deal more might be said on terrestrial radiation, which is one of the most interesting subjects in meteorology; but such considerations would carry me beyond the scope of the present address.

It was stated above that a portion of the sun's heat when falling on the earth was transformed into motion. Perhaps the most striking illustration of the conversion of solar heat into motion, is the effect of the sun under the tropics. Here the sun sheds its rays from overhead at noon, heating every inanimate object to a temperature barely allowing of the contact of the hand;

but men and animals come and go fully exposed to that intense heat, and yet their temperature is either not raised at all, or increased but to a very trifling extent. Again, trees and plants, although fixed to the earth on which they grow, and incapable of motor power, transform a large quantity of the sun's heat into motion to minister to their growth. This heat is given off again when wood is burned, indeed, the warmth emitted by our coal fires is equal to the amount of heat the coals, under the form of plants and trees, have abstracted from the sun to obtain the power of growth. Another form of transformation of heat into motion, and one of very great importance in the phenomena of nature, is the conversion of water into vapour, which is again condensed in the atmosphere, to return under the form of rain. As something like two-thirds of the earth's surface is covered with water, the enormous amount of heat daily disposed of in the formation of vapour is certainly inconceivable.

A very interesting illustration of the direct transformation of heat into motion is afforded by the instrument known as Crookes' Radiometer. A glass globe, in which an incomplete vacuum is made, carries a vertical needle axially fixed. On its summit is poised a rotating system consisting of light horizontal rods, each rod bearing at its extremity a small disc, blackened on one side. Such an instrument placed within reach of a source of heat, has the black sides of the disc more heated than the unblackened sides, and if the radiation be of sufficient energy the vane system rotates. Moonlight is too weak to produce this effect; a candle will make a sensitive radiometer rotate; a paraffin lamp without a globe will, at close quarters, make the vane fly round so fast as to be almost invisible.

The action of heat in Crookes' radiometer is explained as follows:—If a surface be heated, a molecule of gas striking against it is likewise heated, and it leaves the hot surface with a velocity greater than that with which it had approached it. If the surface be fixed, the gas in front of it is driven away, but if the disc be suspended in a partial vacuum, as in the case of Crookes' radiometer, the molecules of air heated by the black surfaces react upon the blackened surface of the vanes and drive them round.

Another illustration of the transformation of heat into motion, or of the mechanical effects of heat upon fluids, is their conversion into what is known as the spheroidal condition. This was first observed by Leidenfrost. When an inverted silver basin has been heated by placing a lamp underneath it, if a sponge full of water be squeezed over it, the drops will roll over the surface of the basin like liquid spheres; every drop as it strikes the hot surface and rolls along it developing vapour, which lifts it out of contact, thus destroying all cohesion between the surface and the drop, and enabling the latter to preserve its spherical or spheroidal form.[1] Mr. Boutigny has given a similar explanation to many extraordinary effects, such as the following:—If the hand be wet it may be passed through a stream of molten metal without injury, because of the moisture assuming the globular form and interposing a bad conductor of heat between the hand and the melted metal. I recollect

[1] Tyndall. *Heat, a Mode of Motion.*

on one occasion, while visiting an iron foundry, dipping my damp finger into a vessel full of molten iron, to the great astonishment of the workmen. If I had here a quantity of melted lead you might see that I could pass two or three wetted fingers through it without any discomfort whatever, or even have the molten lead poured on the back of my hand.

There is a very interesting case on record in which, thanks in a great measure to the spheroid form fluids assume from the action of intense heat, a man swallowed a quantity of molten lead without its effects being immediately fatal. The Eddystone Lighthouse was burnt down on Thursday, December 4th, 1755, at three o'clock in the afternoon. Henry Hall, aged 94 years, of a good constitution, being one of the three men in the lighthouse at the time, was rescued, and with much difficulty returned to his own house at Plymouth. Dr. Spry was sent to see him, and found him in bed complaining of extreme pain all over his body; he told the Doctor, in a hoarse voice scarcely audible, that melted lead had run down his throat into his body. An inspection of the throat, the root of the tongue and contiguous parts, showed indications of severe scorching. On the fourth day he was much better, but growing suddenly worse he expired the day after. The stomach, on examination, was found greatly inflamed and ulcerated, and from its great cavity Dr. Spry took out a piece of lead weighing 7 oz. 5 dr. and 18 grains.

According to the statement made by this man to Dr. Spry: when the accident happened he was endeavouring to extinguish the flames, which were at a considerable height over his head. The lead of the lantern being melted, dropped down upon his face and clothes and into his mouth, which was at the time open.

The account of this remarkable case was sent by Dr. Spry to the Royal Society, but the truth of the occurrence being doubted, the publication of the paper was deferred; the Doctor, however, instituted a number of experiments which turned out thoroughly conclusive, and his report was finally published in the *Philosophical Transactions* for 1756. The present narrative is an abstract from that paper.

The escape of the man from immediate death is accounted for by the melted lead, when pouring down his throat, meeting with wet surfaces of mucous membrane and the moisture assuming the spheroidal form, thus preventing the destruction of these parts beyond surface scorching. On reaching the stomach, in which there was probably some fluid, the lead must have been very rapidly cooled.

After the foregoing survey of the history of the sun's heat, I must now beg briefly to draw your attention to the sun's light.

The passage of the sun's light through our atmosphere alters it in kind to a great and remarkable extent. You will presently see how light can be decomposed into its elementary colours—those of the solar spectrum as seen in rainbows; meanwhile you will be surprised to hear that sunlight is not originally white but bright blue.[1] Its filtration through two atmospheres—

[1] *Daniell's Physics*, p. 438.

that of the sun and that of the earth—renders it yellowish white (Langley). The ultra violet part of the spectrum is enormously brighter at high altitudes.

Light is a vibration of an imponderable matter existing everywhere in space, but this vibration must act upon or within objects let them be ever so small, such as atmospheric dust, to become capable of affecting our sight. Dr. Tyndall's admirable researches on this subject must remain for ever a masterpiece of philosophical research. I shall endeavour to show you his well-known experiment in which a large glass vessel, having been freed from the dust contained in its air, remains dark when a ray of light is made to fall upon it. In this jar the air has been pumped out and let in again through cotton wool a number of times, by so doing its dust has been removed in a very great measure; then, with due precaution, glycerine was let into the jar and made to cover its floor in a thin layer. On leaving the jar untouched for some days, the remaining dust fell upon the glycerine, to which it adhered, leaving the air absolutely pure. You will see that a ray of light made to fall upon this jar disappears within it but reappears on the other side, showing that the power to form light was there though not the material for this power to act upon. You will recollect my telling you that the light of the sun is not a single or elementary colour, but a combination of lights of different colours. This is seen to be the case by placing a prism, best of all a prismatic glass receiver full of carbon bisulphide, in the track of the sun's rays filtered through a small slit into a dark room. The light is refracted and decomposed in the prism, which separates from each other the rays of different refrangibility, and if a screen be placed beyond the prism in such a position that the ray of light as it leaves the prism falls upon the screen, the light is no longer white but shows the seven colours of the rainbow or the solar spectrum in which the violet is at one end and the red at the other. The rainbow is a natural illustration of the decomposition of light; it is seen when the observer is standing between the sun and the rain, the amount of rainbow circle visible at any time depending on the altitude of the sun; if the sun be on the horizon the bow will be semicircular, when the observer is placed on a mountain the bow sometimes forms an entire circle, and we all know that complete circles are occasionally seen in the spray of a waterfall. The phenomenon is due to the sun's rays falling on drops of rain, the ray enters the drop and then undergoes a refraction or a bend in its course, while at the same time it is decomposed into its elementary colours, as would occur in a prism; then the refracted and decomposed ray is reflected towards the observer. Of course no two observers see the same rainbow, although they appear to do so. It is easily shown experimentally that the different colours of the spectrum cannot be further decomposed, as by placing a second prism in the course of any one of the coloured rays there is no further change of colour. On the other hand, the white light of the decomposed ray can be restored in various ways. One of the simplest methods of attaining this object is to throw the spectrum on a concave mirror instead of a screen, when the reflected coloured rays meeting together in the focus of the mirror will appear white on a screen of ground glass. Another plan is to revolve rapidly

a disc on which the seven colours of the spectrum have been painted, when the colours forming one single impression on the retina will appear white or nearly so.

I must now beg to draw your attention to the instruments we possess for measuring the duration of sunlight; they are called "Sunshine Recorders." There are two different instruments used for this purpose in this country, one originally designed by the late Mr. J. F. Campbell, a modification of which by Prof. Stokes is now employed by the Meteorological Office, and the other contrived by Mr. J. B. Jordan in 1885, the record by one of which is published daily in the *Times* newspaper.

In the Campbell-Stokes recorder the rays are received on a sphere of glass and concentrated upon a card placed at the back, the surface of which becomes charred, and so indicates the duration of bright sunshine.

Mr. Jordan's recorder is constructed in such a way that the sun leaves a record of its presence on photographic paper. It consists of a small cylindrical box with two apertures, one admitting the sun's rays before noon and the other after noon. The inside of the box is lined with sensitised paper. The sun shining through the hole forms a trace on the paper. At the end of the day the paper is taken out of the box, the length of the trace is measured, and the sheet dipped in water so that it may be fixed.

Mr. Symons, in an interesting lecture on "Sunshine," delivered at the Royal Botanic Gardens in May 1888, discusses the relative merits of the burning and photographic methods as follows:—

"It seems to me," observes Mr. Symons, "whereas the photographic instruments record sun *light* and the burning ones only sun *shine*, the former ought to give indications during a greater number of hours than the latter; and the table given by Messrs. Jordan and Gaster in the *Quarterly Journal of the Royal Meteorological Society* shows that this was the case in 22 days out of 78.

"*Per contra* we must remember that the photographic paper cannot retain its sensitiveness for ever, whereas the cards for the burning recorders would be just as fit for use half a century after as on the day on which they were purchased; and also that though the fixing of the photographic traces is extremely easy, still it has to be done, and the burning ones require no treatment whatever."

From observations with sunshine recorders from 1880 to 1885, the month of May is found to be that of greatest sunshine. The average yearly total duration of bright sunshine in different parts of the United Kingdom can be estimated, according to Mr. Symons, as 1,850 hours in Jersey against 1,100 hours in London, so that Jersey would receive about one-third more sunshine than London.

I have selected the subject of "The Sun, its Heat and Light," for the present address, as an introduction to the Exhibition of Instruments to which we shall now adjourn. The reports of meteorological observations which appear in so many of our papers, and which are now so widely circulated, assure us of an acquaintance with the instruments in common use for such

observations, and those concerned with the heat and light of the sun will, I am sure, be specially interesting to you as procuring for us knowledge on matters of the highest interest.

ON THE RIME-FROST OF JANUARY 6th and 7th, 1889.

By CHARLES B. PLOWRIGHT, F.L.S.

(Communicated by R. H. Scott, F.R.S.)

[Read April 17th, 1889.]

On Sunday morning, January 6th, 1889, the vicinity of King's Lynn presented a magnificent spectacle of rime-frost. The two previous days had been frosty and with dense fog, but when for a short time on Sunday morning the fog cleared off, the beauty of the rime was very striking.

On the 7th I had an opportunity of observing the phenomenon at Wolferton. Every object seemed to be covered with the rime. The crystals, which were large and well formed, enveloped the objects on all sides, but those on the south or south-west side were larger and greatly elongated. I measured this fringe of crystals upon several twigs and branches, and found it to be between 1½ and 2 inches in length. Towards its base this fringe was much more solid and compact than it was at its free edge, where the crystals were distinct and separate. The same unilateral deposit occurred upon the telegraph wires, so that they became converted into ribbons of icy crystals. A piece of wire netting placed east and west along the side of a field was converted into a sheet of gigantic honeycomb, the cells of which, fully an inch deep, were confined to the south side.

All the overhead telephone wires in King's Lynn were broken down by the weight of the rime during Sunday (6th), and on Monday morning (7th) only one out of the 14 telegraph wires was in working order.

The injuries to the trees were very remarkable and interesting. In the woods and plantations they escaped injury, excepting those which were placed on the southern sides: but those standing alone, either in fields or by the road sides, suffered considerably.

It is remarkable that evergreens, including the firs, escaped injury almost entirely, although these trees are very frequently broken by snow. An isolated Scotch fir at Hillington, however, lost several arms, and a few branches were broken off some trees on the south side of a fir wood at Shortrees. At Wolferton and Sandringham, however, amongst the hundreds of fir trees I only observed one which was broken. The birch trees, on the contrary, suffered considerably, many of them losing more than one branch. A small

tree near Wolferton Station lost an arm which constituted nearly one-third of the tree itself. The oak trees were very much broken, the broken branches and twigs almost invariably remaining attached to the trees. Sometimes the fracture occurred at a joint, sometimes in the continuity of the branch.

The commonest roadside tree in this district, the elm, was quite as much injured as the oak. Sometimes a large arm gave way, but more frequently the smaller branches only suffered; these remained attached, but not for so long a period as the oak branches. The Hon. Miss M. Milles measured one of the largest arms which was broken off an elm tree near Middleton Hall, and found it to be 1 ft. 10 ins. in diameter. This one fell at 5.20 p.m. on the 5th, but it was not perfectly sound.

The larger willows suffered a good deal, the injuries being principally to the larger arms. This was also the case with the weeping willows. Of all the trees none suffered more than the black poplar, a tree which is largely planted in the Fen District. Mr. S. N. Marshall, of West Lynn, who has a number of these trees surrounding his garden, watched the branches come down, one after another, during the morning of Sunday, and when the *débris* was cleared up it amounted to two wagon-loads of fagots. Mr. Alfred Burlingham observed the fall of numerous poplar branches while skating at Islington on Monday the 7th. Mr. Herbert G. Ward, at Terrington St. Clement's, noticed the remarkable manner in which the branches of these trees were gradually bent down by the weight of the rime until they gave way. Mr. S. Egar, of Thorney, near Peterborough, had to cut down a black poplar, which by losing several large arms during the rime so alarmed the inhabitants of a house standing under it that they insisted upon the tree being felled.

Several persons remarked the dark colour of the rime after it had fallen from the trees when the thaw came. Particularly was this the case at Norwich. This dark colour was most likely to be due here to soot. But I observed the same feature at Wolferton on the 9th, and Miss Pung did so at Roydon on the same day. As both these places are small villages, distanced seven or eight miles from the nearest town (Lynn), it seems hardly possible that soot alone could have been the cause.

It is curious how the ash trees escaped injury almost entirely, and this is the more remarkable because many of them were loaded still with their fruit (ash keys), thus affording a considerable surface-area upon which the rime was deposited.[1]

No circumstance connected with this rime was more noticeable than the obstructions to travellers on the public roads. The market carts coming into Lynn on Tuesday morning had to clear away the branches which had fallen during the night, before they could pass. A party of ladies and gentlemen

[1] The rime-frost lasted altogether for nine consecutive days. The reason the ash trees escaped injury was because they relatively have much fewer small twigs than the oak, elms, &c., so that the collective weight each ash tree bore was much less than most other trees.

driving to Narford Lake on Monday were not only impeded by the *débris*, but were at times in considerable alarm lest branches should fall upon them as they passed under some of the trees.

DISCUSSION.

The PRESIDENT (Dr. Marcet) said that he remembered seeing on a foggy day on the St. Theodule pass in Switzerland a line which stretched between two buildings, so completely covered with rime as to be quite invisible, the deposit being fully an inch thick all round it.

Mr. SCOTT called attention to the fact that Mr. Plowright stated that the rime was deposited on one side only of the branches of the trees: and that on Ben Nevis and the Puy de Dôme it was always found that rime deposited itself on the windward side only of objects.

Mr. BUCHAN remarked that the reason why ash trees suffered so little from breakage was owing to the natural toughness of the wood, while birch trees were very brittle.

Mr. WILSON said that at Harpenden the rime was very beautiful. He had found that rime always grew toward the wind. He asked whether the blackened appearance spoken of in the paper could be due to the chemical nature of the deposit.

Mr. INWARDS observed that the bark of the ash was so smooth that possibly the crystals fell off more readily.

Mr. BUCHAN stated that rime was very frequently formed on Ben Nevis. The deposition was always greatest on the windward side, and was in proportion to the strength of the wind. It was sometimes 3 feet in thickness, and formed at the rate of 3 inches an hour. The telegraph cable was placed underground, and was consequently not affected. At the mountain observatories on the continent, the telegraph wires, which were at first placed above ground, were frequently broken by the weight of the rime.

Dr. LAWSON said that he had noticed that generally several days of hard frost occurred before there was any deposit of ice such as was described in this paper, and that the deposition took place after a change of wind to South-west, the greater deposit being on the windward side.

Mr. SYMONS said that the phenomenon of silver thaw was the deposit of very fine rain (or Scotch mist) on cold objects, and the ice so formed was always clear, whereas rime-frost was the deposit of fog, and the crystals composing this rime were always opaque and of a snowy appearance. He believed the intense rime-deposit of January last prevailed over a large area of country extending from Lincolnshire to Berkshire. The attention of the Rev. Leonard Blomefield, the veteran meteorologist of Bath, had been drawn to the intensity of this recent rime-frost, and, in reply, he said that he had only once seen such excessive rime at Swaffam Vicarage, "when all the twigs of the trees, even the slenderest, were so enveloped in long spiculæ standing out perpendicularly to the length of an inch or two at least, as to resemble bottle-brushes. The effects were injurious in some cases, but not to the extent of large boughs of trees being broken." . . . . "Fog, combined with a very low temperature and a perfectly still air, I suppose to be essential conditions." (See also Howard's *Climate of London*, Vol. II. p. 225.)

Dr. TRIPE said he distinctly remembered two occasions on which he had observed the phenomenon of silver thaw, and in each case there was no wind. He believed the absence of wind under other similar conditions, except the presence of wind, had caused a silver thaw instead of the phenomena mentioned in the paper.

Mr. SCOTT remarked that a silver-thaw was a deposition of moisture on objects of low temperature, while glazed frost was generally supposed to occur when snow on the ground had thawed superficially and a fresh frost had ensued.

Mr. CURTIS said he remembered two remarkable instances of silver-thaw occurring in London, the first and most striking of which was on the evening of January 22nd, 1867. On that occasion the streets were completely covered with

a coating of clear ice, upon which persons were able to skate, and which rendered locomotion of any other kind very difficult indeed. The moisture could, however, be distinctly heard to fall as rain upon an open umbrella, although the umbrella itself was covered with a sheet of ice, which rendered it almost impossible to close it until the ice had been thawed. The second instance occurred on the evening of January 1st, 1875, when again the streets were glazed with a similar coating of ice, which almost entirely stopped vehicular traffic, and caused many accidents to pedestrians. The atmospheric conditions which accompanied the phenomena were similar on both occasions. An unusually severe frost had prevailed for several days, and had rendered the ground extremely cold; then the arrival of a depression in the West brought with it a warmer current of air whose moisture was deposited as rain; but this coming into contact with the chilled ground, or with other cold bodies near it, at once froze and formed the coating of ice. On both occasions the temperature rose very quickly, and the silver-thaw was followed by warmer weather.

Mr. BUCHAN said that sometimes the ladder and other objects at the Ben Nevis Observatory were covered with a coating of solid uncrystallised transparent ice, which was of quite a different formation to that of rime. He would ascertain between what temperatures the rime was formed.

ON THE DEATHS CAUSED BY LIGHTNING IN ENGLAND AND WALES from 1852 to 1880, as recorded in the Returns of the Registrar-General.

By ROBERT LAWSON, Inspector-General of Hospitals, LL.D., F.S.S., F.R.Met.Soc.

[Received January 22nd.—Read April 17th, 1889.]

In a paper on the Results of an Investigation of the Phenomena of English Thunderstorms during the years 1857-59,[1] read before this Society in November last, by Mr. Symons, allusion was made to the numbers of persons killed or injured by lightning in the year, and he expressed a hope that some Fellow of the Society, who had access to the Returns of the Registrar-General, would be induced to extend the record as far as the details in them might admit. Having the complete series of these Reports in my possession, I have gone over them carefully, and now submit the results for the consideration of the Royal Meteorological Society.

The deaths from lightning, in England and Wales, are shown in a separate form, for the first time, in the Nineteenth Annual Report, for 1856, p. 179, where there is a table of the total deaths from this cause for each year from 1852 to 1856, with the sex and ages, registration districts and counties in which they happened, and in subsequent Reports, up to 1880 inclusive, these are given in detail, together with their localities, and dates of occurrence. After 1880 the deaths are shown in the general table of dis-

[1] *Quarterly Journal*, Vol. XV. p. 1.

eases, for males and females separately, with their ages, but there is no notice of the localities where they occurred, or of their dates.

The deaths from lightning during the twenty-nine years 1852-1880 amounted to 546; the number fluctuated considerably in different years, thus in 1868 there were 8 only, in 1864 6, and in 1869 7, while in 1852 there were 45, and in 1872 46; the average during the period being 19. Numbers so limited do not afford a basis altogether satisfactory for generalisation, but by grouping them in periods of a series of years their inequalities may be neutralised to a considerable extent, and some useful indications arrived at.

In the first part of the following Table A the deaths have been grouped in the three periods 1852-60, 1861-70, and 1871-80, for England and Wales, and for each of the eleven Registration Divisions. In the second part the mean annual rate of these deaths on a population, assumed at 10,000,000 in England and Wales, and in each division, are given for each group, and in the last column the general mean of each of them for the twenty-nine years.

TABLE A.

England and Wales and Divisions.	Deaths from Lightning in Under-mentioned Periods.			Average Annual Rates per 10,000,000 living.			
	1852 to 1860.	1861 to 1870.	1871 to 1880.	1852 to 1860.	1861 to 1870.	1871 to 1880.	1852 to 1880.
England and Wales ..	176	139	231	10·50	6·50	9·54	8·79
I. Metropolis	3	1	8	1·28	·33	2·28	1·30
II. South Eastern ..	11	9	29	7·00	4·48	12·54	8·04
III. South Midland ..	14	11	25	12·27	8·03	16·54	12·28
IV. Eastern	14	16	14	13·77	13·55	10·97	12·73
V. South Western ..	12	6	12	7·32	3·23	6·41	5·58
VI. West Midland ..	31	19	29	14·97	7·35	10·12	10·67
VII. North Midland ..	19	26	27	16·81	19·29	17·85	18·02
VIII. North Western ..	20	13	29	8·13	4·11	7·80	6·63
IX. York	23	22	29	13·35	9·97	11·04	11·39
X. Northern.....	15	7	16	15·62	5·46	10·61	10·38
XI. Welsh	14	9	13	12·38	6·62	8·79	9·12

From these numbers it appears that the deaths in the country generally in 1852-60 were 10·50 in ten millions living, these fell to 6·50 in 1861-70, and rose again in 1871-80 to 9·54, the mean for the whole period being 8·79. A corresponding fluctuation is found in five of the eleven divisions, though in these the rates for 1852-60 are higher than that for 1871-80 in some instances, and in others the contrary.

The exceptional cases are the IV. division, embracing the counties of Essex, Suffolk, and Norfolk, in which the rate in 1861-70 was about the same as that in the preceding period, followed by a considerable fall in 1871-80, and the VII. division, containing the counties of Leicester, Rutland, Lincoln, Nottingham, and Derby, in which the ratio in 1861-70 was considerably higher than in either the preceding or following period. From the

last column it appears the lowest ratio of deaths was in the I. division or the metropolis, next to this comes the V., comprising the counties of Wilts, Dorset, Devon, Cornwall, and Somerset, with a ratio of 5·58, and then the VIII. division, or Cheshire and Lancashire, with a ratio of 6·68. The highest ratios were 12·78 in the IV. division and 18·02 in the VII. accompanying the peculiar fluctuation already mentioned.

In consequence of their greater exposure, the inhabitants of rural districts suffer more from lightning than those of towns, and the mortality from this in the different divisions will vary according to the relative proportions of the rural and urban populations in them. Besides this, however, the ratios in the last column indicate there are at least two other conditions which modify the results considerably, viz. vicinity to the west and south coasts, which reduces the chances of injury from lightning, and distance from the coast and high land, which seems to increase them. Thus the ratio of deaths from this cause is lowest in the metropolis, being only 1·80, then follows the V., or south-western, division with 5·58, next the VIII., or north-western division, with 6·68, in which vicinity to the west coast and predominance of urban population concur to produce this result, then comes the II., or south-eastern, division with 8·04; all these are under 8·79, the mean for England and Wales. The IX., or Welsh, division, which embraces westerly exposure and much high land, has a ratio of 9·12. The ratio in the VI., or west-midland, division at the top of the Bristol Channel is 10·67, while that in the III., the south-midland, more in the centre of the country, is 12·28, and that of the VII., or north-midland, both inland and elevated, is 18·02, the highest of all. The IV., or eastern division, has the high ratio of 12·78, which contrasts strongly with those for the west coast. The IX. division or Yorkshire, and the X., embracing the four northern counties, extending from the east to the west coast, and with much high land, have ratios of 11·39 and 10·38 respectively.

The following Table B shows the total deaths from lightning in each of the three periods given in Table A, together with their distribution between the sexes and their ages.

TABLE B.

Periods.	Total both Sexes.	Males.												Females.											
		Total.	0—.	5—.	10—.	15—.	20—.	25—.	35—.	45—.	55—.	65—.		Total.	0—.	5—.	10—.	15—.	20—.	25—.	35—.	45—.	55—.	65—.	
1852–60	176	149	3	5	16	29	19	29	15	18	11	4		27	1	2	5	4	5	4	2	2	2	..	
1861–70	139	104	..	5	7	8	7	22	22	13	10	10		35	2	2	5	1	4	3	4	5	4	5	
1871–80	231	189	..	8	23	20	20	32	31	20	24	11		42	2	3	1	3	2	9	2	9	6	5	
1852–80	546	442	3	18	46	57	46	83	68	51	45	25		104	5	7	11	8	11	16	8	16	12	10	

From these figures it is obvious that of the 546 deaths, extending over a period of twenty-nine years, 442, or 81 per cent., were of males, and 104 only, or 19 per cent., of females, and the proportions in the shorter periods do not

differ very materially from this. The greatest number of deaths among the males in the Table was from 25 to 85, but as the age periods before 25 embrace five years only, the deaths under each require to be doubled to render them comparable with those that follow; making this correction, the deaths from 10 to 15 would have amounted to 92, from 15 to 20 to 114, and from 20 to 25 to 92, showing that in general terms males between 15 and 20 years of age were exposed to most risk.

As stated above, there were 546 deaths from lightning in England and Wales from 1852 to 1880. Of these there were in 1852 45 deaths, in 1853 10, 1854 17, 1855 17, and in 1856 14, 103 in all, which were not referred to the different months in the Returns. From 1857 to 1880 the dates of occurrence were given, and the deaths are shown in each month for each year in the following Table C:—

TABLE C.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Totals.
1857	..	..	..	..	2	4	4	6	2	..	..	..	18
1858	..	..	..	1	5	11	3	6	..	..	..	..	26
1859	..	..	1	..	3	5	7	..	..	..	..	1	17
1860	..	..	..	..	..	7	4	..	..	..	..	1	12
Sum	..	..	1	1	10	27	18	12	2	..	..	2	73
1861	..	..	..	..	2	12	9	1	1	1	..	..	26
1862	..	..	..	..	4	3	3	..	1	1	..	..	12
1863	..	1	..	..	..	1	..	1	..	..	..	..	3
1864	..	..	1	..	4	1	..	..	..	..	..	..	6
1865	..	..	..	..	2	..	12	6	..	..	..	..	20
1866	..	..	..	..	..	13	2	2	1	..	..	..	18
1867	..	..	1	1	2	1	3	1	8	..	..	..	17
1868	..	..	..	1	4	1	1	3	..	..	..	1	11
1869	..	..	2	1	1	..	..	..	3	..	..	..	7
1870	..	..	..	..	1	3	5	8	..	2	..	..	19
Sum	..	1	4	3	20	35	35	22	14	4	..	1	139
1871	..	..	..	2	1	9	10	5	1	..	..	..	28
1872	..	..	..	1	3	16	15	8	3	..	..	..	46
1873	1	..	..	1	..	3	7	5	2	2	..	..	21
1874	..	..	1	..	4	4	9	5	2	..	..	..	25
1875	..	..	..	..	..	6	4	5	2	..	..	..	17
1876	..	..	..	2	1	8	1	4	2	1	..	..	19
1877	..	..	1	..	3	..	3	3	..	1	1	..	12
1878	..	..	1	..	1	1	4	17	..	..	..	..	24
1879	..	..	..	..	2	6	1	5	..	1	..	..	15
1880	..	..	..	..	1	12	7	2	2	..	..	..	24
Sum	1	..	3	6	16	65	61	59	14	5	1	..	231
Totals ..	1	1	8	10	46	127	114	93	30	9	1	3	443
Per Cent.	·2	·2	1·8	2·3	10·4	28·7	25·7	21·0	6·7	2·0	·2	·7	100·0

Taking the whole period deaths occurred in every month, but they were most frequent in June and July, and somewhat less so in August,—in these

three months 75·5 per cent. of the whole took place; in 1872, even when there were 46 killed by this cause, 39 of them were in these three months, and 7 only in April, May, and September.

The space over which deaths from lightning are found on the same, or successive days, is often very great; in June 1871, for instance, there were nine from the 19th to the 21st inclusive, in July six on the 5th, and in August four on the 18th. These were distributed as under:—

Date.	Division.	County.	Place of Death.
June 19th	VI.	Stafford	Wolverhampton
,,	VII.	Lincoln	Bourne
,,	VII.	Do.	Louth
June 20th	II.	Kent	Romney
,,	II.	Sussex	Lewes
,,	II.	Hants	Winchester
,,	V.	Wilts	Cricklade
,,	VIII.	Lancaster	Wigan
June 21st	VIII.	Do.	Haslingden
July 5th	II.	Kent	Hoo
,,	III.	Buckingham	Newport Pagnell
,,	III.	Do.	Do.
,,	III.	Northampton	Potterspring
,,	IV.	Norfolk	Loddon
,,	IX.	York, North Riding	Whitby
Aug. 18th	VII.	Derby	Bakewell
,,	VIII.	Lancaster	Ashton-under-Lyne
,,	IX.	York, West Riding	Ecclesall Bierlou
,,	X.	Durham	Auckland

Again, on June 18th, 1872, there were eleven deaths from this cause, distributed as follow:—

Date.	Division.	County.	Place of Death.
June 18th	VI.	Hereford	Kington
,,	VI.	Shropshire	Whitchurch
,,	VI.	Stafford	Walsall
,,	VI.	Do.	Do.
,,	VII.	Nottingham	Radford
,,	IX.	York, West Riding	Todmorden
,,	IX.	Do.	Halifax
,,	IX.	Do.	Tadcaster
,,	X.	Northumberland	Newcastle-on-Tyne
,,	X.	Do.	Tynemouth
,,	X.	Westmoreland	Kendal

From 1857 to 1880 there were twenty-one instances of two persons being killed by lightning in the same sub-district on the same day, and two

instances in which there were three, these 48 deaths amount to 10·8 per cent. on the 443 recorded in these 24 years. There was no such occurrence in the 9 years 1858, 1860, 1862, 1863, 1864, 1865, 1870, 1877, 1878. There were single instances in 1866, 1867, 1868, 1871, 1872, 1874, 1879. There were two instances in each of the years 1857, 1859, 1861, 1869, 1873, 1875, 1876, 1880. As to locality, there was none in the Registrar-General's I. division, one each in the III., IV., V. and XI. divisions, two in the IX., three each in VI., VIII. and X. divisions, and four each in the II. and VII. divisions. The frequency of these multiple deaths did not, as a rule, fall on years when the deaths in the country at large were most numerous.

The deaths from lightning are not given separately in the returns of the Registrars-General for Scotland and Ireland, so no information on the subject is available for these countries.

DISCUSSION.

Mr. SYMONS said he was glad that Dr. Lawson had adopted the hint he had thrown out in his paper on English Thunderstorms. He had stated in his paper on the thunderstorms of 1857-9, when speaking on the accidents caused by lightning, that possibly the figures he had obtained were not one-fourth of the actual number, and Dr. Lawson's Tables bore out this assertion, for the actual deaths in these years were 18, 26 and 17 respectively, while the instances of deaths given in his paper were 5, 7 and 8. It was curious that the smallest number of deaths occurred in the Metropolitan District, especially when the density of its population was considered. M. Flammarion had pointed out that in the case of Paris the absence of deaths from lightning was very remarkable, and he had explained it by the fact that the number of lightning conductors attached to the churches and various large buildings in that city served to carry off the electric discharge, and so cases of deaths from lightning strokes were very rare. Possibly a similar explanation was applicable in the case of our own metropolis.

Mr. WILSON thought that the electricity might be diffused in large towns by various agencies available for silently carrying it off, such as lamp posts, metal pipes, and even, perhaps, by tall buildings, though not protected by lightning conductors.

Dr. TRIPE said that the fact of the great excess of deaths of males as compared with females was due to the former being more engaged in field labour and outdoor occupations. He believed more deaths were caused by what are called upward strokes than by direct downward lightning flashes.

Mr. LECKY was glad to hear Dr. Tripe allude to upward currents, for he believed the major portion of accidents arose from such, and that these and other disruptions were very much occasioned by the intense heat instantaneously engendered by the electrical resistance of the conductors through which the currents passed. A flash of lightning was really the result of atmospheric resistance, and he was of opinion that lightning was purely an effect, not a cause.

Capt. MACLEAR said it would be interesting to obtain the proportion of destructive storms to the total number of thunderstorms experienced. At Cranleigh, 9 miles south-east of Guildford, where he lived, thunderstorms were of very rare occurrence, but damage was very frequently done when they did occur. He then described the experience of two platelayers in a thunderstorm which took place at Cranleigh on April 9th.

Mr. BUCHAN referred to the number of cattle frequently killed by lightning, and suggested that the congregating and huddling together of the animals when a thunderstorm was in progress caused a great ascension of heated moist air, which served to conduct the lightning to the cattle. He thought that the Royal

Agricultural Society might be able to render valuable assistance in collecting statistics of the number of animals, &c. killed by lightning. He then made some remarks concerning the winter thunderstorms experienced in the North and North-west of Scotland.

Dr. LAWSON, in reply, said that he had simply given facts, and had made no attempt to draw deductions, excepting such as were indicated plainly by the figures themselves. As to the influence of buildings in lessening the risks from lightning, alluded to by one speaker, he mentioned that on one occasion, during a tornado at night, the officers' barrack at Sierra Leone, a two-storied building on Tower Hill, an isolated height 400 feet above the sea, was struck by lightning, the report resembling an irregular discharge of musketry. He was in bed at the time, but quite awake, and though there was a closed verandah outside the room, which excluded the light from the ordinary flashes of lightning going on around, yet in this instance it was brightly illuminated, and every thing in it was visible. The building had lead along the ridge and down the hips of the roof in the usual manner; this was in connection with the waterways and eaves gutters, and iron pipes led from these to the ground; there was also an iron framework of joists and pillars, supporting the verandah all round the building. No one was hurt, and there was no trace of injury to the building, though there was no regular lightning conductor fitted to it. A similar metallic communication from the ridge to the ground would no doubt preserve other buildings from injury by lightning, though they had no special appliance fitted for its discharge.

THE DIURNAL RANGE OF THE BAROMETER IN GREAT BRITAIN AND IRELAND.

Derived from the Hourly Records of the 9 Principal Observatories in the Kingdom during the Years 1876-80.

By FRANCIS CAMPBELL BAYARD, LL.M., F.R.Met.Soc.

(Plate II.-X.)

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BEFORE commencing this paper I wish to tender my thanks to all those friends who have helped me in this work, and in particular to the Meteorological Council, the Astronomer-Royal, Mr. Hartnup, Mr. Scott, Mr. Ellis, Mr. Baldwin Latham, Mr. Symons, Mr. Eaton and Mr. Marriott, but to the two last especially.

There are extant eleven hourly records of the barometer during the lustrum 1876-80, viz. 1st, the records of the seven Observatories in connection with the Meteorological Office:—Valencia and Armagh in Ireland; Glasgow and Aberdeen in Scotland; and Falmouth, Stonyhurst, and Kew in England; 2nd, the record of the Royal Observatory, Greenwich; 3rd, the record of the Liverpool Observatory at Bidston; and 4th, two untabulated records, one belonging to Messrs. Davis and Son, opticians, Derby, which is complete from April 10th, 1876, and the other belonging to the Midland Institute, Birmingham, which is complete with the exception of the last five months of 1879.

The Radcliffe Observatory at Oxford had a barograph, the records of which

began in 1855, but from 1876-79 inclusive the records were too defective and incomplete to be worth tabulating, and in 1880 the old barograph was replaced by one lent by the Meteorological Office.

This paper deals with the whole of the tabulated records mentioned, and with respect to these a few words seem desirable.

1st. The hourly records of the seven observatories are tabulated and printed, but with the exception of the years included in this paper the hourly means have not yet been calculated. I have, however, lately had the great pleasure of learning that the Meteorological Council have undertaken to compute the hourly means of these records, which will greatly enhance their value and make them generally available. They extend in a complete form from 1870-88, a period of 14 years. At the end of 1888 the Council discontinued the observatories of Armagh, Glasgow, and Stonyhurst, but have kept on the remaining four to the present time.

2nd. The hourly records of the barometer at the Royal Observatory, Greenwich, extend from 1854 to the present time, but there is a gap in the tabulations between 1874-76, which is now being supplied, and with reference to this I should like to add my testimony to the public spirit displayed by the Observatory Authorities, for when application was made for the tabulations of 1876 I was told of the existence of this gap, but on representing that it would be a great pity if the barometer records were not included in this paper, I was informed that the tabulations in question formed part of a larger work which had been resolved upon, and the barometer records of 1876 would be done first.

3rd. The hourly records of the Liverpool Observatory at Bidston extend from 1866 to the present time, and are duly tabulated and the hourly means worked out; they are not, however, entirely comparable with the other records mentioned, owing to the barograph being set to sea-level. I am indebted to Mr. Hartnup for being enabled to include these reductions.

With respect to the barographs used at the different stations, a photographic barograph, of the pattern adopted by the Meteorological Office, is used at the seven observatories, a photographic siphon barograph at Greenwich, and a King's Mechanical Barograph at Bidston. The barographs are compared with standard barometers and corrected for temperature at all the observatories except at Bidston, where the instrument is also set to sea-level.

With respect to the reductions of the hourly records, Mr. Eaton had in 1878 done the year 1876 for each of the seven observatories, and the remaining four years have been done by myself, with, as regards the year 1877, some slight assistance from the papers of the late Mr. Charles Greaves, which have been kindly placed in my hands by Mr. Baldwin Latham. Deficient observations have been provided for by interpolation, Mr. Eaton's figures being adopted for the year 1876 and the Meteorological Office figures for the remaining four years. These tabulations begin at 1 a.m. and end at midnight.

With respect to Greenwich, the reductions have been done at the Observatory and deficient observations supplied, the smaller interpolations being

made at the Observatory, and two larger ones, comprising many consecutive days by myself, from the hourly readings of Kew Observatory, corrected by the eye readings made four times a day at Greenwich Observatory. The tabulations begin at midnight and end at 11 p.m.; and, in order to make them comparable, the midnight p.m. has been kindly calculated for me at the Observatory.

With respect to Bidston, the reductions have been done at the Observatory, and deficient observations there supplied. The tabulations begin at midnight and end at 11 p.m.; and, in order to make them comparable, the figures for the midnight p.m. have been kindly supplied to me by Mr. Hartnup, and I have reduced them.

Greenwich mean time is used at all the Observatories.

Tables 1-9 give the average hourly monthly readings of the barometer at each Observatory for the lustrum 1876-80.

The actual tables on which the results in Tables 1-9 are based will be printed *in extenso* by the Meteorological Council, and published by them as an Appendix to the *Quarterly Weather Report* for 1880; and I must here express my sincere thanks to that body for their kindness in so doing. In the tables printed by the Meteorological Council the 25th hour, viz. 1 a.m. after midnight, has in all cases been added. This has been done in order to complete the daily period, and has been calculated by excluding the 1 a.m. observation for the 1st of the month and including that of the 1st of the following month; as, for instance, for January, it would be obtained from the 31 observations commencing with 1 a.m. on January 2nd and ending with 1 a.m. on February 1st.

For Greenwich the 1 a.m., after midnight, was calculated for me at the Observatory, whilst for Bidston the necessary data were supplied to me. In the tables printed by the Meteorological Council the first 12 for each place give the mean hourly reading of the barometer for every month, first for each year of the lustrum and then for the five years combined; the next one gives the mean hourly reading for each year and also for the whole period; and the final one exhibits for each month the diurnal range of the barometer or the difference between the mean for the day and the means for each hour as given in the last column of the first 12 tables. For the purpose of this final table, which has been calculated by the Meteorological Office, the means as given in the last columns of the first 12 tables have been corrected for the non-periodic change, which is shown by the differences between the means for the terminal hours of the days (the two 1 a.m. means) to have taken place during the interval. The differences, which are commonly large enough to cause considerable irregularities in the diurnal curve, have been dealt with thus:—calling the difference between the initial and terminal readings d, the following corrections have been applied to the daily series:—

a.m. 1	2	3		Noon	1 p.m.	2 p.m.		11 p.m.	midnt.	1 a.m.
12	11	10		1		1		10	11	12
$\pm d$	$\pm d$	$\pm d$	...	$\pm d$	0	$\pm d$	...	$\pm d$	$\pm d$	$\pm d$,
24	24	24		24		24		24	24	24

the correction being added during the first half of the day and subtracted

during the latter half if the initial mean value be lower than the final, and *vice versâ*. To the mean for the whole day a correction has been applied to make it the mean for the 25 hours. The values given in these tables of daily range are also exhibited in the series of diagrams accompanying this paper (Plates II.-X.).

In the following pages I propose to give a short description of each Observatory, which with regard to the seven observatories has in the main been taken from Vol. II. of the *Quarterly Weather Report*, and with respect to Greenwich and Bidston has been drawn up by myself and revised by Mr. Ellis and Mr. Hartnup respectively; to indicate shortly the prevailing wind or winds, for which purpose certain wind records have been investigated; and to point out any peculiarities in the diurnal barometric range in the accompanying diagrams (Plates II. to X.).

Valencia.

This Observatory is situate in lat. 51° 55′ N and long. 10° 18′ W on the extreme western coast of Ireland, close to the shore of the sound, about three miles from the open sea. There are hills to the South and South-east of the height of from 1,000 to 1,200 ft. about three miles distant, and a hill to the North-west of the height of 700 ft. about three-quarters of a mile away. The barograph is placed in the same room with the standard barometer, the cistern of which is 28 ft. above mean sea-level. The prevailing wind is Westerly, but South-easterly, Southerly, South-westerly, and North-westerly winds are also very prevalent.

The monthly and yearly curves of diurnal range are very largely influenced by the numerous cyclones which come in from the Atlantic. The third small maximum in the winter months, mentioned by Mons. Rykatchew, is shown at 8 a.m. in January and December, and some slight symptoms of it also appear in the month of February. The morning minimum, which varies in time according to the rising of the sun, is much more pronounced than the afternoon minimum, which sometimes seems almost to vanish, as in the June curve. The evening maximum, about 10 p.m., is more pronounced and of greater amplitude than the morning one during the spring and summer in March, April, May, June, July and August. In the yearly curve the evening maximum is more pronounced than the morning one, and the morning minimum than the afternoon one.

Armagh.

This Observatory is situate in lat. 54° 21′ N and long. 6° 39′ W, on rising ground close to the town of Armagh, in the centre of an ordinary garden and pleasure ground containing trees and shrubs of moderate size. The country round is undulating and very fairly wooded, which has the effect of greatly retarding the movement of the air, calms being very frequent. The barograph is in the same room as the standard barometer, the cistern of which is 207 ft. above mean sea-level. The prevailing wind is South-westerly.

The monthly and yearly curves of diurnal range appear to be very largely influenced by the great number of calms prevalent here, for they have a

smoothness which is in striking contrast to the Valencia curves. The third small maximum in the winter months appears here about 8 a.m. in January and December. Attention may also be called to the fact that there appears to be an indication of a small maximum about 8 p.m. in June and July, and that symptoms of it appear in May, August and September. The afternoon minimum is more pronounced than the morning one in March, April, May, November, and December, whilst in the other months the morning minimum is more prominent. The evening maximum is of greater amplitude than the morning one in April, May, June, July, August, and October, whilst the morning one is greater in the remaining months. In the yearly curve the morning maximum is greater than the afternoon one.

Glasgow.

This Observatory is situate in lat. 55° 53′ N and long. 4° 18′ W, on slightly rising ground on the West side of the town. It occupies a central position in the valley of the Clyde, which is here about 16 miles in breadth. The bounding hills to the North are about 800 ft. in height, and to the South about 400 ft., but beyond these respectively are higher ranges of over 1,100 ft. elevation. The barograph is in the same room as the standard barometer, the cistern of which is 184 ft. above mean sea-level. The prevailing wind is South-westerly, but Westerly and North-Westerly winds are also very frequent.

The monthly and yearly curves of diurnal range are very peculiar, and it would seem that the irregularities are to a certain extent due to the position of the Observatory. Attention is drawn to the snake-like appearance of the curve in February, July, October, November, and December, a peculiarity to some extent reproduced in the yearly curve. The small morning maximum is shown in the January curve at 8 a.m., and there are slight symptoms of it at 2 a.m. in February, November, and December. The afternoon minimum is of greater amplitude than the morning one during March, April, May, June, July, August, October, and December, and in the yearly curve. The evening maximum, unlike that of the Irish Observatories, is not nearly so prominent, being only greater than the morning maximum during March, May, June, July, and August.

Aberdeen.

This Observatory is situate in lat. 57° 10′ N and long. 2° 6′ W, at King's College in Old Aberdeen, on a plain gradually rising from the sea, from which it is distant about a mile. The ground rises gradually on the North to about 300 ft., and on the West and South-west to about 800 ft. There are no irregularities in the vicinity except the two river valleys of the Dee and the Don, which, though not of much importance, necessarily to some extent influence the direction of the wind. The ground immediately about the buildings is 46 ft. above mean sea-level. The barograph is placed in the same room as the standard barometer, the cistern of which is 89 ft. above mean sea-level. The prevailing wind is South-westerly, but North-westerly winds are very frequent.

The monthly and yearly curves of diurnal range are fairly smooth, but the most striking feature is their very small amplitude except in January and September. Attention is directed to the flatness of the curves in May, June, July, and August. The early morning maximum in winter is slightly seen at 2 a.m. in the November and December curves. The morning maximum is most prominent in January, October, November and December, whilst the afternoon one is more pronounced in the curves of the remaining months and in the yearly curves. The morning minimum is more pronounced in the January, February, April, May, June, August, September, November, December and yearly curves, whilst the afternoon one is more prominent in the curves of the remaining months.

Falmouth.

This Observatory was situate in lat. 50° 9′ N and long. 5° 4′ W, at the South-east corner of the Bowling-green on the top of one of the hills on which the town is built.[1] There is a range of hills on the West side of the town at a distance of about 6 miles about 550 ft. in height. The barograph is placed in the same room as the standard barometer, the cistern of which is 211 ft. above mean sea-level. The prevailing winds are South-westerly, Westerly, and North-westerly.

The monthly and yearly curves of diurnal range are here fairly smooth. Attention may be drawn to the remarkable flattening of the curve in the months of June, July and August at noon and 1 p.m. There is also a very peculiar slackening in the rise of the morning maximum at 9 a.m., which runs through the four months from May to August inclusive. In the month of June the afternoon minimum nearly disappears as at Valencia. The early morning maximum in winter is slightly seen at 8 a.m. in December and January. The evening maximum is more pronounced than the morning one in April, June and July, and also slightly so in August. Throughout the whole of the curves, with the single exception of the November curve, the morning minimum is of greater amplitude than the afternoon one.

Stonyhurst.

This Observatory is situate in lat. 53° 51′ N and long. 2° 28′ W, in the centre of the garden of Stonyhurst College, near Whalley. It stands on a gentle slope facing South-south-east, not far from the river Hodder, and the country round, including the College grounds, is wooded, but not very thickly so, and the trees in general are small. There are some hills of considerable height not far distant, viz. Longridge Fell on the North-west of the height of about 1,000 ft. about 2½ miles distant; Easington Fell on the North of the height of 1,300 ft. about 7 miles away; and Pendle Hill on the East of 1,800 ft. about 6½ miles off. The barograph is placed in a different room from the standard barometer, the cistern of which is 361 ft. above mean sea level. The prevailing winds are South-westerly and Westerly, but North-easterly ones are also very frequent.

[1] A new Observatory was built in the year 1885.

With respect to the monthly and yearly curves of diurnal range attention may be directed to the peculiar oscillations in the June, July and August curves. An obvious slackening in the rise of the morning maximum between 8 and 9 a.m. runs through all the curves with the exception of those for May and September. Symptoms of the early morning maximum in the winter months occur in the January, November and December curves at 8 a.m., but they are not well marked. Attention may also be directed to the greater amplitude of the evening maximum over the morning one in the curves for the warm season, April, May, June, July, August and September; and also to the very peculiar slackening between 11 p.m. and midnight in the descent of this evening maximum in the curves for January, February, March, July, August, October, November and December. The afternoon minimum is of greater amplitude than the morning one in February, March, April, May, June, and October.

Kew.

This Observatory is situate in lat. 51° 28′ N and long. 0° 19′ W, in the Old Deer Park at Richmond, Surrey. Its position in the Thames Valley is on the whole a good and open one, though there is a row of trees about 150 yards off on the West side, and the country round is fairly wooded. The barograph is placed in a different room from the standard barometer, the cistern of which is 84 ft. above mean sea-level. The prevailing wind is South-westerly.

The monthly and yearly curves of diurnal range deserve particular notice, because of the very great amplitude of the afternoon minimum in January, March, April, May, June, July, August, October, and December, and, indeed, throughout the whole set of curves the morning minimum is small as compared with the afternoon one. The early morning maximum in the winter months is very clearly shown in the January curve at 2 a.m., and traces of it appear in the February and December curves. The evening maximum is more pronounced in April, May, June, July and August, than the morning one. Altogether the curves of this observatory present a much smoother appearance than those of any other observatory previously mentioned.

Greenwich.

The Magnetical and Meteorological Department of the Royal Observatory is situate in lat. 51° 29′ N and long. 0° 0′ on the rising ground in Greenwich Park, in the County of Kent, about 170 ft. South-south-east from the nearest point of the South-east Dome of the Astronomical Observatory. The standard barometer, by Newman, is fixed on the Southern wall of the Upper Magnet room; the diameter of its tube is 0·565 in. and its cistern is 159 ft. above mean sea-level. The barograph is fixed to the North wall of the Magnetic basement, which is below the Upper Magnet room. The variation in temperature in the Magnetic basement is very small, and in no sensible degree affects the results obtained from the barograph in the manner in which the sheets are treated. The variation in temperature in the Upper

Magnet room is that of an ordinary indoor apartment, and the readings of the standard barometer are of course corrected for temperature before combination with the photographic ordinates for the determination of the value of the photographic base line. An elaborate comparison made by Mr. Whipple in 1877 showed that the readings of the Greenwich and Kew standard barometers agreed within ·001 in. Further particulars in regard to the Greenwich barometers will be found in the Introductions to the several volumes of the *Greenwich Magnetical and Meteorological Observations*. The prevailing wind at the observatory, on the average of the five years, is South-westerly.

The monthly and yearly curves of diurnal range, though of the same general character as those of Kew, distant only about 10 miles, exhibit certain peculiarities which it is well to note. The early morning maximum in the winter months is well shown in the January curve at 2 a.m., and there are traces of it in the February, November and December curves. Attention may be called to the sudden rise in the afternoon maximum in January between 6 and 7 p.m., and the flatness of the morning maximum between 10 and 11 a.m. in January, March and November, and 9 and 10 a.m. in April, June, and September. In other respects the Kew and Greenwich curves are very much alike, except that the Greenwich ones are slightly smoother than the Kew ones, and in the yearly curve the afternoon minimum does not seem quite so pronounced as at Kew.

BIDSTON.

The Liverpool Observatory is situate in lat. 58° 24′ 4″ N and long. 8° 4′ 17″ W, upon the summit of Bidston Hill near Birkenhead, 200 ft. above mean sea-level. The building is on the North side of the hill, and the ground gradually recedes from the site in every direction with the exception of a few degrees between South and South-east, where it is nearly of the same elevation for the distance of two or three miles. The barograph and the standard barometer are placed in the chronometer-room on the ground floor, the cistern of the standard being 197 ft. above mean sea-level. The prevailing wind is Westerly.

The monthly and yearly curves of diurnal range are somewhat like those of Valencia. Some of the peculiarities are doubtless due to the reduction to sea-level. The early morning maximum in the winter months is shown at 8 a.m. in the December curve. The flatness of the curve in June and July, and the flatness of the morning maximum in July and August, are noticeable. In the yearly curve the afternoon minimum is more pronounced than the morning one. The afternoon maximum is of greater amplitude than the morning one in the warmer season, April, May, June, July, August, and September, and in the latter month the sudden rise of the afternoon maximum is noticeable. Attention may also be drawn to the flatness of the afternoon maximum in January, February, March, May, June, November, and December. The curves, in conclusion, present an appearance of smoothness, which one would rather have looked for in those of Kew and Greenwich than at the more westerly station of Bidston.

TABLE I.—MEAN BAROMETER READINGS AT VALENCIA FOR YEARS 1876–80.

Height of Barometer 23 ft. above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·9922	29·7874	29·8892	29·7168	29·9680	29·8586	29·9540	29·8264	29·9272	29·8686	29·8802	29·8192	29·8740	1 a.m.
2	·9874	·7790	·8856	·7118	·9612	·8516	·9464	·8208	·9212	·8654	·8750	·8154	·8684	2
3	·9864	·7744	·8788	·7074	·9554	·8454	·9406	·8148	·9144	·8586	·8710	·8164	·8636	3
4	·9820	·7688	·8728	·7050	·9502	·8406	·9378	·8102	·9096	·8568	·8658	·8126	·8594	4
5	·9788	·7682	·8718	·7038	·9492	·8414	·9382	·8092	·9062	·8562	·8626	·8068	·8577	5
6	·9776	·7700	·8742	·7088	·9542	·8458	·9420	·8142	·9104	·8594	·8624	·8060	·8604	6
7	·9802	·7716	·8760	·7140	·9568	·8500	·9458	·8186	·9164	·8628	·8626	·8080	·8637	7
8	·9884	·7790	·8812	·7198	·9616	·8560	·9512	·8252	·9224	·8724	·8700	·8136	·8701	8
9	29·9968	·7834	·8840	·7226	·9636	·8596	·9526	·8278	·9256	·8790	·8742	·8208	·8742	9
10	30·0064	·7884	·8890	·7266	·9668	·8638	·9554	·8320	·9306	·8848	·8792	·8294	·8794	10
11 a.m.	·0112	·7910	·8906	·7290	·9672	·8676	·9574	·8344	·9322	·8856	·8790	·8322	·8815	11 a.m.
Noon	30·0080	·7920	·8900	·7292	·9686	·8698	·9588	·8344	·9312	·8850	·8706	·8258	·8803	Noon
1 p.m.	29·9990	·7854	·8872	·7270	·9672	·8704	·9582	·8342	·9294	·8786	·8604	·8162	·8761	1 p.m.
2	·9934	·7774	·8810	·7280	·9654	·8706	·9586	·8334	·9266	·8730	·8534	·8108	·8726	2
3	·9910	·7706	·8744	·7230	·9622	·8694	·9562	·8306	·9224	·8676	·8462	·8078	·8685	3
4	·9940	·7684	·8728	·7202	·9584	·8682	·9542	·8286	·9192	·8674	·8464	·8136	·8676	4
5	29·9970	·7686	·8724	·7200	·9564	·8660	·9522	·8272	·9182	·8684	·8482	·8170	·8676	5
6	30·0014	·7756	·8780	·7222	·9564	·8656	·9528	·8268	·9194	·8750	·8542	·8210	·8707	6
7	·0034	·7806	·8842	·7246	·9578	·8658	·9548	·8282	·9210	·8812	·8578	·8234	·8736	7
8	·0082	·7818	·8902	·7308	·9622	·8670	·9590	·8342	·9262	·8838	·8616	·8270	·8777	8
9	·0096	·7798	·8932	·7356	·9682	·8706	·9634	·8386	·9278	·8850	·8632	·8286	·8803	9
10	·0104	·7816	·8950	·7358	·9720	·8734	·9670	·8400	·9286	·8872	·8664	·8300	·8823	10
11 p.m.	·0086	·7794	·8944	·7334	·9700	·8704	·9654	·8376	·9276	·8852	·8638	·8290	·8804	11 p.m.
Midnight ..	30·0082	29·7784	29·8938	29·7330	29·9668	29·8654	29·9624	29·8342	29·9252	29·8832	29·8638	29·8276	29·8783	Midnight
Mean of above 24 hours	29·9967	29·7784	29·8833	29·7220	29·9619	29·8614	29·9535	29·8276	29·9225	29·8738	29·8641	29·8191	29·8720	Mean of above 24 hours
1 a.m. after Midnight	30·0032	29·7744	29·8898	29·7292	29·9606	29·8572	29·9576	29·8300	29·9220	29·8796	29·8590	29·8228	29·8738	1 a.m. after Midnight

TABLE II.—Mean Barometer Readings at ARMAGH for Years 1876-80.

Height of Barometer 207 ft. above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·7994	29·5480	29·6446	29·5566	29·7702	29·6618	29·6956	29·6264	29·6868	29·6732	29·6486	29·5886	29·6583	1 a.m.
2	·7990	·5432	·6420	·5514	·7642	·6568	·6894	·6208	·6830	·6680	·6450	·5858	·6541	2
3	·7990	·5374	·6356	·5466	·7604	·6522	·6832	·6160	·6786	·6624	·6422	·5854	·6499	3
4	·7968	·5336	·6298	·5426	·7562	·6488	·6792	·6126	·6760	·6592	·6380	·5812	·6462	4
5	·7956	·5328	·6296	·5426	·7566	·6490	·6786	·6120	·6772	·6592	·6382	·5780	·6458	5
6	·7958	·5322	·6314	·5472	·7602	·6524	·6812	·6156	·6822	·6610	·6366	·5774	·6478	7
7	·8014	·5344	·6352	·5536	·7634	·6554	·6854	·6206	·6898	·6648	·6388	·5806	·6520	6
8	·8084	·5402	·6394	·5584	·7658	·6592	·6886	·6252	·6956	·6734	·6446	·5868	·6571	8
9	·8172	·5454	·6440	·5604	·7676	·6604	·6898	·6278	·6990	·6784	·6484	·5934	·6610	9
10	·8240	·5482	·6466	·5622	·7646	·6602	·6898	·6284	·7002	·6800	·6508	·5978	·6627	10
11 a.m.	·8262	·5524	·6468	·5628	·7642	·6586	·6902	·6290	·6990	·6814	·6520	·6004	·6646	11 a.m.
Noon	·8206	·5494	·6442	·5606	·7622	·6572	·6894	·6276	·6972	·6786	·6430	·5916	·6601	Noon
1 p.m.	·8122	·5416	·6388	·5588	·7612	·6552	·6894	·6262	·6948	·6734	·6352	·5842	·6559	1 p.m.
2	·8040	·5332	·6304	·5552	·7568	·6514	·6868	·6226	·6900	·6682	·6266	·5770	·6502	2
3	·8034	·5288	·6256	·5514	·7538	·6506	·6868	·6208	·6872	·6664	·6226	·5764	·6478	3
4	·8038	·5260	·6224	·5482	·7496	·6474	·6828	·6174	·6832	·6644	·6230	·5778	·6455	4
5	·8064	·5270	·6236	·5492	·7492	·6464	·6828	·6170	·6838	·6680	·6264	·5804	·6467	5
6	·8090	·5328	·6280	·5522	·7492	·6488	·6830	·6170	·6864	·6744	·6290	·5826	·6494	6
7	·8116	·5366	·6340	·5574	·7538	·6526	·6880	·6208	·6908	·6804	·6300	·5864	·6535	7
8	·8146	·5368	·6386	·5664	·7592	·6564	·6928	·6278	·6960	·6842	·6302	·5890	·6577	8
9	·8160	·5384	·6420	·5724	·7682	·6632	·7004	·6332	·6972	·6884	·6310	·5914	·6618	9
10	·8184	·5386	·6440	·5752	·7690	·6660	·7030	·6352	·6954	·6880	·6308	·5918	·6630	10
11 p.m.	·8186	·5380	·6440	·5768	·7688	·6662	·7040	·6358	·6938	·6878	·6324	·5932	·6633	11 p.m.
Midnight ..	29·8180	29·5366	29·6438	29·5764	29·7664	29·6622	29·7016	29·6332	29·6900	29·6856	29·6330	29·5932	29·6617	Midnight
Mean of above 24 hours	29·8091	29·5380	29·6369	29·5577	29·7609	29·6558	29·6892	29·6237	29·6897	29·6737	29·6365	29·5863	29·6548	Mean of above 24 hours.
1 a.m. after Midnight	29·8156	29·5324	29·6428	29·5742	29·7636	29·6596	29·6966	29·6280	29·6860	29·6826	29·6284	29·5898	29·6583	1 a.m. after Midnight

TABLE III.—MEAN READINGS OF THE BAROMETER AT GLASGOW FOR YEARS 1876–80.

Height of Barometer 184 ft. above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·7898	29·5246	29·6090	29·5844	29·7604	29·6602	29·6506	29·6230	29·6564	29·6562	29·6124	29·5596	29·6406	1 a.m.
2	·7912	·5208	·6050	·5810	·7560	·6564	·6462	·6182	·6528	·6518	·6104	·5598	·6375	2
3	·7918	·5134	·5986	·5778	·7520	·6522	·6414	·6138	·6472	·6470	·6064	·5576	·6333	3
4	·7890	·5090	·5944	·5756	·7498	·6528	·6384	·6088	·6438	·6456	·6042	·5534	·6304	4
5	·7876	·5072	·5920	·5770	·7506	·6540	·6384	·6090	·6442	·6446	·6044	·5486	·6298	5
6	·7894	·5070	·5930	·5836	·7546	·6580	·6412	·6124	·6500	·6464	·6060	·5478	·6325	6
7	·7930	·5088	·5976	·5892	·7568	·6612	·6440	·6160	·6574	·6508	·6088	·5490	·6361	7
8	·8026	·5160	·6022	·5934	·7582	·6632	·6466	·6202	·6630	·6578	·6166	·5534	·6411	8
9	·8112	·5186	·6056	·5952	·7570	·6614	·6464	·6206	·6660	·6610	·6198	·5600	·6436	9
10	·8186	·5210	·6062	·5946	·7544	·6596	·6468	·6210	·6684	·6640	·6252	·5676	·6456	10
11 a.m.	·8220	·5250	·6054	·5940	·7528	·6572	·6452	·6200	·6674	·6636	·6252	·5666	·6454	11 a.m.
Noon	·8162	·5216	·6024	·5896	·7488	·6550	·6454	·6178	·6650	·6590	·6188	·5604	·6417	Noon
1 p.m.	·8084	·5142	·5982	·5874	·7458	·6516	·6432	·6156	·6632	·6524	·6104	·5532	·6370	1 p.m.
2	·8040	·5066	·5912	·5832	·7418	·6486	·6424	·6132	·6606	·6482	·6038	·5498	·6328	2
3	·8026	·5012	·5868	·5790	·7376	·6438	·6390	·6106	·6570	·6444	·5998	·5466	·6290	3
4	·8044	·5004	·5850	·5766	·7346	·6410	·6370	·6084	·6548	·6446	·5998	·5488	·6280	4
5	·8066	·5026	·5864	·5780	·7336	·6398	·6362	·6066	·6562	·6484	·6012	·5484	·6287	5
6	·8100	·5102	·5938	·5826	·7356	·6426	·6400	·6090	·6604	·6560	·6056	·5536	·6333	6
7	·8108	·5118	·5998	·5890	·7404	·6446	·6424	·6144	·6654	·6598	·6040	·5542	·6364	7
8	·8126	·5132	·6042	·5986	·7480	·6518	·6480	·6250	·6704	·6628	·6054	·5596	·6416	8
9	·8134	·5124	·6062	·6022	·7550	·6580	·6528	·6278	·6696	·6634	·6030	·5604	·6437	9
10	·8144	·5140	·6078	·6056	·7578	·6626	·6578	·6314	·6694	·6658	·6040	·5632	·6462	10
11 p.m.	·8118	·5120	·6070	·6076	·7582	·6626	·6560	·6298	·6670	·6638	·6012	·5612	·6449	11 p.m.
Midnight ..	29·8116	29·5124	29·6068	29·6086	29·7568	29·6610	29·6546	29·6288	29·6630	29·6640	29·6000	29·5616	29·6441	Midnight
Mean of above 24 hours	29·8047	29·5127	29·5994	29·5889	29·7499	29·6541	29·6450	29·6176	29·6599	29·6551	29·6082	29·5560	29·6376	Mean of above 24 hours
1 a.m. after Midnight	29·8094	29·5084	29·6032	29·6062	29·7540	29·6568	29·6514	29·6252	29·6594	29·6612	29·5948	29·5578	29·6407	1 a.m. after Midnight

TABLE IV.—Mean Readings of the Barometer at ABERDEEN for Years 1876–80.

Height of Barometer 89 ft. above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·8804	29·6138	29·6932	29·7260	29·8714	29·7864	29·7468	29·7438	29·7524	29·7544	29·7006	29·6458	29·7429	1 a.m.
2	·8808	·6104	·6888	·7224	·8674	·7814	·7418	·7400	·7492	·7508	·6988	·6458	·7398	2
3	·8794	·6050	·6814	·7194	·8630	·7766	·7366	·7342	·7432	·7452	·6942	·6438	·7352	3
4	·8776	·5998	·6762	·7168	·8598	·7762	·7348	·7320	·7388	·7438	·6922	·6386	·7322	4
5	·8756	·5960	·6754	·7180	·8616	·7768	·7356	·7310	·7386	·7436	·6922	·6344	·7316	5
6	·8772	·5942	·6758	·7244	·8652	·7796	·7376	·7328	·7436	·7456	·6932	·6328	·7335	6
7	·8810	·5962	·6770	·7304	·8676	·7828	·7408	·7362	·7478	·7508	·6972	·6336	·7368	7
8	·8896	·6010	·6810	·7356	·8700	·7868	·7426	·7394	·7516	·7564	·7044	·6382	·7414	8
9	·8986	·6036	·6838	·7394	·8708	·7870	·7426	·7412	·7552	·7592	·7080	·6436	·7444	9
10	·9042	·6052	·6856	·7416	·8710	·7878	·7418	·7418	·7566	·7610	·7118	·6508	·7466	10
11 a.m.	·9090	·6078	·6882	·7428	·8708	·7882	·7420	·7430	·7582	·7626	·7138	·6516	·7482	11 a.m.
Noon	·9040	·6060	·6864	·7430	·8698	·7872	·7408	·7416	·7584	·7590	·7078	·6464	·7459	Noon
1 p.m.	·8990	·5992	·6814	·7426	·8680	·7858	·7390	·7400	·7566	·7532	·7024	·6408	·7423	1 p.m.
2	·8978	·5926	·6772	·7406	·8670	·7852	·7384	·7394	·7544	·7484	·6972	·6392	·7398	2
3	·8980	·5888	·6730	·7364	·8628	·7828	·7356	·7368	·7524	·7448	·6948	·6388	·7371	3
4	·8996	·5896	·6724	·7358	·8612	·7794	·7338	·7356	·7522	·7436	·6956	·6402	·7366	4
5	·9020	·5940	·6756	·7364	·8594	·7770	·7338	·7352	·7556	·7464	·6968	·6396	·7377	5
6	·9050	·5996	·6818	·7404	·8620	·7782	·7368	·7382	·7608	·7520	·6984	·6404	·7411	6
7	·9064	·6014	·6870	·7468	·8662	·7802	·7410	·7430	·7678	·7556	·6980	·6416	·7446	7
8	·9090	·6024	·6900	·7536	·8720	·7838	·7462	·7508	·7718	·7576	·6978	·6438	·7482	8
9	·9076	·6016	·6916	·7550	·8754	·7890	·7518	·7530	·7708	·7580	·6960	·6448	·7496	9
10	·9068	·6028	·6920	·7554	·8758	·7904	·7542	·7542	·7690	·7592	·6950	·6470	·7502	10
11 p.m.	·9054	·6022	·6914	·7550	·8736	·7888	·7524	·7534	·7654	·7580	·6922	·6468	·7487	11 p.m.
Midnight ..	29·9040	29·6012	29·6900	29·7542	29·8706	29·7858	29·7502	29·7502	29·7620	29·7576	29·6900	29·6470	29·7469	Midnight
Mean of above 24 hours	29·8958	29·6006	29·6832	29·7380	29·8676	29·7835	29·7415	29·7411	29·7555	29·7528	29·6987	29·6423	29·7417	Mean of above 24 hours
1 a.m. after Midnight	29·9008	29·5972	29·6862	29·7502	29·8662	29·7820	29·7468	20·7456	29·7578	29·7562	29·6850	29·6432	29·7431	1 a.m. after Midnight

TABLE V.—MEAN READINGS OF THE BAROMETER AT FALMOUTH FOR YEARS 1876–80.

Height of the Barometer 211 feet above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·8884	29·6796	29·7168	29·5606	29·7690	29·7176	29·7756	29·6724	29·7628	29·7136	29·7066	29·6816	29·7204	1 a.m.
2	·8872	·6748	·7098	·5534	·7622	·7090	·7682	·6656	·7568	·7084	·7034	·6804	·7149	2
3	·8854	·6690	·7012	·5480	·7570	·7024	·7612	·6598	·7502	·7010	·6988	·6790	·7094	3
4	·8796	·6628	·6956	·5432	·7524	·6982	·7580	·6554	·7464	·6980	·6940	·6750	·7049	4
5	·8750	·6622	·6950	·5424	·7538	·6988	·7596	·6554	·7444	·6978	·6932	·6710	·7041	5
6	·8744	·6626	·6970	·5484	·7594	·7036	·7644	·6618	·7510	·7006	·6932	·6722	·7074	6
7	·8794	·6640	·7018	·5540	·7642	·7094	·7706	·6686	·7580	·7070	·6958	·6762	·7124	7
8	·8878	·6724	·7086	·5586	·7694	·7148	·7772	·6756	·7658	·7174	·7046	·6844	·7202	8
9	·8962	·6780	·7136	·5624	·7708	·7176	·7798	·6782	·7704	·7226	·7098	·6918	·7243	9
10	·9036	·6822	·7180	·5674	·7728	·7208	·7828	·6818	·7752	·7276	·7120	·7008	·7288	10
11 a.m.	·9104	·6894	·7232	·5718	·7772	·7250	·7866	·6846	·7760	·7312	·7138	·7040	·7328	11 a.m.
Noon	·9018	·6862	·7216	·5700	·7758	·7258	·7860	·6858	·7742	·7272	·7014	·6926	·7290	Noon
1 p.m.	·8914	·6784	·7168	·5702	·7748	·7262	·7856	·6858	·7704	·7206	·6940	·6820	·7247	1 p.m.
2	·8842	·6684	·7078	·5672	·7724	·7264	·7840	·6854	·7648	·7158	·6864	·6756	·7199	2
3	·8852	·6630	·7026	·5628	·7680	·7258	·7820	·6810	·7604	·7132	·6842	·6764	·7171	3
4	·8882	·6628	·6992	·5624	·7650	·7242	·7798	·6792	·7586	·7134	·6848	·6794	·7164	4
5	·8920	·6658	·6996	·5642	·7622	·7224	·7776	·6770	·7586	·7158	·6878	·6826	·7171	5
6	·8978	·6722	·7050	·5670	·7614	·7238	·7770	·6768	·7606	·7216	·6918	·6872	·7202	6
7	·9018	·6768	·7094	·5706	·7636	·7252	·7788	·6782	·7636	·7252	·6930	·6908	·7231	7
8	·9054	·6766	·7142	·5780	·7682	·7278	·7816	·6852	·7702	·7274	·6948	·6946	·7270	8
9	·9068	·6772	·7156	·5812	·7750	·7354	·7884	·6876	·7702	·7296	·6970	·6968	·7301	9
10	·9082	·6762	·7176	·5806	·7750	·7372	·7896	·6882	·7704	·7312	·6982	·6984	·7309	10
11 p.m.	·9076	·6746	·7156	·5794	·7728	·7330	·7866	·6856	·7668	·7280	·6964	·6964	·7286	11 p.m.
Midnight ..	29·9056	29·6736	29·7132	29·5780	29·7688	29·7280	29·7832	29·6834	29·7626	29·7268	29·6948	29·6942	29·7260	Midnight
Mean of above 24 hours.	29·8935	29·6729	29·7091	29·5642	29·7671	29·7199	29·7777	29·6766	29·7629	29·7175	29·6971	29·6860	29·7204	Mean of above 24 hours
1 a.m. after Midnight	29·9008	29·6692	29·7092	29·5728	29·7628	29·7198	29·7768	29·6772	29·7570	29·7240	29·6888	29·6886	29·7206	1 a.m. after Midnight

TABLE VI.—Mean Readings of the Barometer at STONYHURST for Years 1876-80.

Height of Barometer 361 ft. above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·6738	29·4084	29·4706	29·4010	29·5912	29·5136	29·5100	29·4642	29·5210	29·5178	29·4644	29·4308	29·4972	1 a.m.
2	·6742	·4038	·4670	·3980	·5874	·5088	·5054	·4592	·5160	·5138	·4626	·4314	·4940	2
3	·6736	·3968	·4588	·3932	·5824	·5050	·4986	·4528	·5098	·5078	·4572	·4286	·4887	3
4	·6706	·3928	·4552	·3914	·5792	·5050	·4972	·4490	·5070	·5058	·4546	·4250	·4861	4
5	·6678	·3912	·4552	·3920	·5796	·5054	·4984	·4478	·5072	·5048	·4552	·4212	·4855	5
6	·6680	·3916	·4588	·3988	·5830	·5090	·5024	·4510	·5144	·5070	·4554	·4228	·4885	6
7	·6714	·3936	·4628	·4032	·5850	·5112	·5054	·4534	·5204	·5128	·4592	·4242	·4919	7
8 ...	·6818	·4010	·4676	·4060	·5866	·5142	·5092	·4586	·5258	·5202	·4672	·4322	·4975	8
9 ...	·6890	·4034	·4686	·4068	·5850	·5134	·5084	·4600	·5290	·5226	·4704	·4368	·4995	9
10	·6980	·4078	·4710	·4086	·5834	·5136	·5104	·4614	·5326	·5238	·4746	·4446	·5025	10
11 a.m.	·7002	·4088	·4710	·4060	·5808	·5128	·5112	·4612	·5312	·5222	·4718	·4422	·5016	11 a.m.
Noon	·6930	·4052	·4684	·4032	·5792	·5112	·5114	·4610	·5312	·5180	·4654	·4350	·4985	Noon
1 p.m.	·6836	·3960	·4606	·4000	·5746	·5070	·5096	·4580	·5272	·5112	·4564	·4274	·4926	1 p.m.
2	·6800	·3892	·4542	·3968	·5724	·5046	·5096	·4564	·5244	·5078	·4506	·4232	·4891	2
3	·6784	·3850	·4478	·3902	·5680	·5004	·5068	·4528	·5194	·5040	·4478	·4226	·4853	3
4	·6816	·3850	·4448	·3894	·5666	·4972	·5042	·4518	·5182	·5048	·4510	·4264	·4851	4
5	·6842	·3876	·4460	·3898	·5650	·4950	·5018	·4486	·5196	·5092	·4538	·4270	·4856	5
6	·6886	·3954	·4538	·3962	·5688	·4972	·5036	·4518	·5248	·5170	·4570	·4298	·4903	6
7	·6924	·3970	·4586	·4038	·5736	·5008	·5058	·4558	·5306	·5206	·4580	·4326	·4941	7
8	·6968	·3986	·4638	·4162	·5824	·5074	·5108	·4666	·5368	·5238	·4606	·4352	·4999	8
9	·6976	·3992	·4654	·4202	·5904	·5156	·5170	·4706	·5360	·5260	·4586	·4370	·5028	9
10	·6976	·3994	·4664	·4228	·5930	·5200	·5194	·4738	·5352	·5278	·4588	·4382	·5044	10
11 p.m.	·6978	·3978	·4644	·4236	·5918	·5194	·5172	·4718	·5316	·5264	·4560	·4386	·5030	11 p.m.
Midnight ..	29·6974	29·3988	29·4646	29·4234	29·5898	29·5172	29·5152	29·4712	29·5280	29·5264	29·4538	29·4376	29·5020	Midnight
Mean of above 24 hours	29·6849	29·3972	29·4611	29·4034	29·5808	29·5085	29·5079	29·4587	29·5241	29·5159	29·4592	29·4313	29·4944	Mean of above 24 hours
1 a.m. after Midnight	29·6924	29·3940	29·4630	29·4192	29·5854	29·5128	29·5102	29·4658	29·5226	29·5232	29·4480	29·4328	29·4975	1 a.m. after Midnight

TABLE IX.—Mean Readings of the Barometer at BIDSTON for Years 1876–8[1].

Height of Barometer 197 ft. above Mean Sea Level.[1]

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	30·0752	29·8054	29·8702	29·7830	29·9808	29·8964	29·9048	29·8456	29·9122	29·9072	29·8690	29·8318	29·8901	1 a.m.
2	·0744	·8004	·8666	·7782	·9778	·8914	·8986	·8408	·9074	·9030	·8656	·8294	·8861	2
3	·0738	·7960	·8606	·7756	·9714	·8878	·8930	·8350	·9028	·8960	·8616	·8278	·8818	3
4	·0716	·7912	·8556	·7726	·9680	·8864	·8908	·8308	·8982	·8944	·8590	·8242	·8786	4
5	·0684	·7906	·8558	·7720	·9674	·8854	·8914	·8294	·8960	·8938	·8584	·8214	·8775	5
6	·0680	·7906	·8576	·7764	·9714	·8888	·8926	·8306	·9012	·8952	·8590	·8206	·8793	6
7	·0706	·7926	·8620	·7816	·9738	·8926	·8972	·8356	·9090	·9012	·8632	·8236	·8836	7
8	·0798	·7996	·8672	·7860	·9770	·8972	·9018	·8412	·9166	·9092	·8698	·8310	·8897	8
9	·0906	·8030	·8702	·7896	·9774	·8980	·9034	·8436	·9214	·9130	·8740	·8388	·8936	9
10	·0952	·8038	·8702	·7880	·9770	·8966	·9042	·8436	·9220	·9118	·8742	·8420	·8941	10
11 a.m.	·0974	·8042	·8694	·7854	·9728	·8952	·9054	·8430	·9222	·9118	·8720	·8418	·8934	11 a.m.
Noon	·0914	·8008	·8676	·7820	·9700	·8924	·9056	·8420	·9204	·9094	·8638	·8358	·8901	Noon
1 p.m.	·0822	·7942	·8614	·7784	·9672	·8898	·9050	·8406	·9174	·9028	·8562	·8286	·8853	1 p.m.
2	·0760	·7874	·8528	·7744	·9638	·8870	·9040	·8380	·9142	·8990	·8506	·8240	·8809	2
3	·0752	·7830	·8462	·7696	·9594	·8842	·9016	·8336	·9108	·8962	·8480	·8234	·8776	3
4	·0774	·7826	·8424	·7690	·9566	·8814	·8986	·8308	·9088	·8964	·8494	·8238	·8764	4
5	·0810	·7854	·8432	·7714	·9566	·8812	·8970	·8298	·9122	·9002	·8534	·8256	·8781	5
6	·0852	·7914	·8494	·7758	·9582	·8816	·8962	·8310	·9164	·9078	·8564	·8278	·8814	6
7	·0892	·7932	·8542	·7826	·9622	·8852	·8982	·8358	·9192	·9118	·8584	·8306	·8851	7
8	·0930	·7938	·8594	·7926	·9684	·8902	·9020	·8426	·9252	·9136	·8580	·8332	·8893	8
9	·0972	·7930	·8616	·7988	·9758	·8966	·9084	·8482	·9246	·9160	·8584	·8342	·8927	9
10	·0960	·7932	·8620	·8018	·9792	·9002	·9106	·8514	·9240	·9162	·8588	·8356	·8941	10
11 p.m.	·0964	·7940	·8624	·8044	·9794	·9002	·9102	·8526	·9214	·9176	·8570	·8358	·8943	11 p.m.
Midnight ..	30·0960	29·7940	29·8628	29·8024	29·9780	29·8988	29·9082	29·8520	29·9170	29·9164	29·8552	29·8360	29·8931	Midnight
Mean of above 24 hours	30·0834	29·7943	29·8596	29·7830	29·9704	29·8910	29·9012	29·8395	29·9142	29·9058	29·8604	29·8303	29·8861	Mean of above 24 hours
1 a.m. after Midnight	30·0936	29·7914	29·8624	29·8010	29·9740	29·8960	29·9054	29·8472	29·9130	29·9140	29·8514	29·8336	29·8903	1 a.m. after Midnight

[1] The readings of this Table are reduced to sea-level.

TABLE VIII.—Mean Readings of the Barometer at GREENWICH for Years 1876-80.

Height of Barometer 159 ft. above Mean Sea Level.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	29·9522	29·7086	29·7314	29·6310	29·8138	29·7652	29·7764	29·7120	29·7864	29·7751	29·7234	29·7224	29·7582	1 a.m.
2	·9544	·7052	·7272	·6272	·8076	·7604	·7710	·7068	·7826	·7704	·7218	·7216	·7547	2
3	·9524	·6984	·7208	·6242	·8032	·7572	·7678	·7026	·7766	·7660	·7184	·7210	·7507	3
4	·9484	·6944	·7182	·6212	·8008	·7568	·7676	·6994	·7734	·7640	·7152	·7176	·7481	4
5	·9458	·6930	·7182	·6230	·8026	·7598	·7700	·7012	·7742	·7654	·7156	·7140	·7486	5
6	·9472	·6920	·7216	·6290	·8072	·7632	·7740	·7046	·7802	·7684	·7178	·7144	·7516	6
7	·9514	·6938	·7260	·6350	·8102	·7674	·7786	·7100	·7870	·7770	·7228	·7170	·7564	7
8	·9590	·7004	·7306	·6376	·8136	·7700	·7810	·7134	·7926	·7826	·7304	·7236	·7612	8
9	·9648	·7044	·7344	·6396	·8124	·7702	·7814	·7158	·7972	·7844	·7348	·7308	·7642	9
10	·9702	·7082	·7352	·6410	·8116	·7706	·7806	·7166	·7980	·7856	·7388	·7364	·7661	10
11 a.m.	·9716	·7108	·7342	·6388	·8100	·7682	·7804	·7160	·7954	·7842	·7376	·7332	·7650	11 a.m.
Noon	·9622	·7062	·7306	·6342	·8058	·7632	·7762	·7126	·7912	·7774	·7294	·7248	·7595	Noon
1 p.m.	·9534	·6978	·7220	·6298	·8004	·7578	·7732	·7094	·7870	·7706	·7216	·7162	·7533	1 p.m.
2	·9500	·6906	·7148	·6248	·7974	·7550	·7704	·7064	·7826	·7660	·7148	·7124	·7488	2
3	·9508	·6864	·7094	·6176	·7918	·7508	·7656	·7020	·7788	·7638	·7140	·7138	·7454	3
4	·9534	·6860	·7068	·6170	·7888	·7478	·7624	·6996	·7766	·7632	·7148	·7168	·7444	4
5	·9570	·6888	·7080	·6200	·7874	·7456	·7600	·6982	·7770	·7680	·7170	·7208	·7457	5
6	·9602	·6952	·7146	·6248	·7898	·7484	·7616	·6998	·7808	·7768	·7202	·7230	·7496	6
7	·9658	·6986	·7212	·6332	·7946	·7526	·7656	·7056	·7880	·7804	·7204	·7260	·7543	7
8	·9678	·6996	·7250	·6432	·8032	·7582	·7716	·7150	·7932	·7832	·7206	·7286	·7591	8
9	·9692	·7012	·7256	·6472	·8114	·7684	·7792	·7200	·7948	·7868	·7216	·7296	·7629	9
10	·9700	·7010	·7254	·6496	·8144	·7722	·7830	·7218	·7944	·7870	·7206	·7306	·7642	10
11 p.m.	·9718	·7008	·7246	·6528	·8150	·7728	·7828	·7212	·7936	·7860	·7194	·7320	·7644	11 p.m.
Midnight ..	29·9700	29·6992	29·7230	29·6516	29·8132	29·7704	29·7814	29·7184	29·7896	29·7836	29·7158	29·7292	29·7621	Midnight
Mean of above 24 hours	29·9591	29·6984	29·7229	29·6331	29·8044	29·7613	29·7734	29·7095	29·7863	29·7757	29·7220	29·7232	29·7558	Mean of above 24 hours
1 a.m. after Midnight	29·9668	29·6960	29·7208	29·6472	29·8090	29·7652	29·7774	29·7128	29·7856	29·7818	29·7104	29·7264	29·7583	1 a.m. after Midnight

TABLE IX.—Mean Readings of the Barometer at BIDSTON for Years 1876–8[1].

Height of Barometer 197 ft. above Mean Sea Level.[1]

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Hours.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
1 a.m.	30·0752	29·8054	29·8702	29·7830	29·9808	29·8964	29·9048	29·8456	29·9122	29·9072	29·8690	29·8318	29·8901	1 a.m.
2	·0744	·8004	·8666	·7782	·9778	·8914	·8986	·8408	·9074	·9030	·8656	·8294	·8861	2
3	·0738	·7960	·8606	·7756	·9714	·8878	·8930	·8350	·9028	·8960	·8616	·8278	·8818	3
4	·0716	·7912	·8556	·7726	·9680	·8864	·8908	·8308	·8982	·8944	·8590	·8242	·8786	4
5	·0684	·7906	·8558	·7720	·9674	·8854	·8914	·8294	·8960	·8938	·8584	·8214	·8775	5
6	·0680	·7906	·8576	·7764	·9714	·8888	·8926	·8306	·9012	·8952	·8590	·8206	·8793	6
7	·0706	·7926	·8620	·7816	·9738	·8926	·8972	·8356	·9090	·9012	·8632	·8236	·8836	7
8	·0798	·7996	·8672	·7860	·9770	·8972	·9018	·8412	·9166	·9092	·8698	·8310	·8897	8
9	·0906	·8030	·8702	·7896	·9774	·8980	·9034	·8436	·9214	·9130	·8740	·8388	·8936	9
10	·0952	·8038	·8702	·7880	·9770	·8966	·9042	·8436	·9220	·9118	·8742	·8420	·8941	10
11 a.m.	·0974	·8042	·8694	·7854	·9728	·8952	·9054	·8430	·9222	·9118	·8720	·8418	·8934	11 a.m.
Noon	·0914	·8008	·8676	·7820	·9700	·8924	·9056	·8420	·9204	·9094	·8638	·8358	·8901	Noon
1 p.m.	·0822	·7942	·8614	·7784	·9672	·8898	·9050	·8406	·9174	·9028	·8562	·8286	·8853	1 p.m.
2	·0760	·7874	·8528	·7744	·9638	·8870	·9040	·8380	·9142	·8990	·8506	·8240	·8809	2
3	·0752	·7830	·8462	·7696	·9594	·8842	·9016	·8336	·9108	·8962	·8480	·8234	·8776	3
4	·0774	·7826	·8424	·7690	·9566	·8814	·8986	·8308	·9088	·8964	·8494	·8238	·8764	4
5	·0810	·7854	·8432	·7714	·9566	·8812	·8970	·8298	·9122	·9002	·8534	·8256	·8781	5
6	·0852	·7914	·8494	·7758	·9582	·8816	·8962	·8310	·9164	·9078	·8564	·8278	·8814	6
7	·0892	·7932	·8542	·7826	·9622	·8852	·8982	·8358	·9192	·9118	·8584	·8306	·8851	7
8	·0930	·7938	·8594	·7926	·9684	·8902	·9020	·8426	·9252	·9136	·8580	·8332	·8893	8
9	·0972	·7930	·8616	·7988	·9758	·8966	·9084	·8482	·9246	·9160	·8584	·8342	·8927	9
10	·0960	·7932	·8620	·8018	·9792	·9002	·9106	·8514	·9240	·9162	·8588	·8356	·8941	10
11 p.m.	·0964	·7940	·8624	·8044	·9794	·9002	·9102	·8526	·9214	·9176	·8570	·8358	·8943	11 p.m.
Midnight .	30·0960	29·7940	29·8628	29·8024	29·9780	29·8988	29·9082	29·8520	29·9170	29·9164	29·8552	29·8360	29·8931	Midnight
Mean of above 24 hours	30·0834	29·7943	29·8596	29·7830	29·9704	29·8910	29·9012	29·8395	29·9142	29·9058	29·8604	29·8303	29·8861	Mean of above 24 hours
1 a.m. after Midnight	30·0936	29·7914	29·8624	29·8010	29·9740	29·8960	29·9054	29·8472	29·9130	29·9140	29·8514	29·8336	29·8903	1 a.m. after Midnight

[1] The readings of this Table are reduced to sea-level.

The general conclusions to be drawn from the preceding remarks and from the tables and diagrams accompanying this paper are that:—

1st. Diurnal Range tables of the barometer drawn up from observations made at a single place are practically of no use for any other locality, except perhaps a place within a radius of a few miles from the spot where the observations are made: for it will be found that as a rule (*a*) the curves of inland places are smoother than those of places on the sea coast; (*b*) the curves of places to the westward are more irregular than those of places more to the eastward; and (*c*) as we go from South-east to North-west the general tendency of the curve is to get flatter with a lessened diurnal range.

2nd. The third small maximum in the winter months between 2 a.m. and 8 a.m. tends to disappear as we proceed northward, thereby confirming Mons. Rykatchew's researches.

I have placed in the Society's Library the original working sheets and diagrams from which this paper and the accompanying tables have been compiled, in the hope that they may eventually prove to be of some slight assistance to any one engaged in discussions of a similar nature.

DISCUSSION.

Mr. BUCHAN, after complimenting the author on the quality of his work, said that to secure really good averages of the diurnal variation of the barometer it was necessary to have a series of observations which extended for about 22 years, or two periods of sunspots. He would have preferred to see the day divided in a different manner. It would have been much better to have had two midnights rather than two 1 a.m.'s. He then went on to explain the reason of the difference between the Greenwich and Kew results, attributing it to the fact that the former was situated on a hill, while the latter was in a valley.

Mr. WILSON drew attention to the flatness of the summer curves, as compared with the winter curves.

Mr. EATON observed that at Pekin during the winter the prevalent North-westerly winds were very dry, blowing outwards from the land under the influence of the great accumulation of air over Central Asia; and at that time of year the afternoon depression was greater than that of the early morning. But the reverse obtained in the summer, when low barometric readings were established over that continent. The Southerly and South-easterly winds which then swept over Pekin from the sea were moist, and the type of curve of diurnal range of pressure approached that which was found at Valencia and Falmouth. This favoured the view that aqueous vapour was an important factor in determining the form of curve of diurnal variation of pressure.

Mr. BAYARD, in reply, said that the snake-like appearance of the Glasgow curves was no doubt entirely due to the situation of the Observatory, which was surrounded by high hills.

NOTE ON A WORKING MODEL OF THE GULF STREAM.

By A. W. CLAYDEN, M.A., F.R.Met.Soc., F.G.S.

[Received March 1st—Read April 17th, 1889.]

The apparatus which I have the honour of bringing before the Royal Meteorological Society has been constructed in order to illustrate the formation of ocean currents in general and of the Gulf Stream in particular.

It consists essentially of a shallow wooden tray, about an inch and a quarter in depth. Upon the flat bottom of this are secured a number of pieces of wood or metal, cut to represent the land and raised to a height of about five-eighths of an inch above the base. These form land surfaces, and the body of the tray, which represents the sea, is coloured deep blue.

We have thus a shallow vessel shaped like the map of the Atlantic upon Mercator's Projection, a form which was adopted because it is that upon which charts of the winds and ocean currents are usually drawn. The area represented extends from lat. 45° S to lat. 75° N, and from long. 100° W to long. 85° E; its actual measurements being 14¼ ins. from East to West and 16¾ ins. from North to South.

Two boxes or wind chests connected with a T piece are fixed below the tray, and a number of tubes are introduced from above, the holes being drilled through the wooden continents and tray into the boxes. The kind of tubing used is soft metal gas tubing of the smallest size made. This can be very easily bent and adjusted, but possesses sufficient rigidity to keep in its proper place. The tubes are bent over where they emerge from the land surfaces, and are so directed as to produce a stream of air circulating over the model ocean as nearly as possible in imitation of the actual circulation of the winds over the real Atlantic. Of course the resemblance cannot be perfect, as an exact reproduction would necessitate so many tubes as to hide the ocean whose movements we wish to study.

The Trades are represented by eleven tubes; five for the Southern Trades, five for the Northern Trades over the main ocean, and one for the Northerly Trade in the Bay of Campeachy. An inspection of the air jets shows that the circulation is approximately correct.

The Anti-trades are in each case represented by three tubes, and there is one other to produce the Northerly wind prevalent on the coast of Labrador during winter.

If now the model ocean be filled with water, and the surface of the liquid is rendered visible by scattering over it a small quantity of Lycopodium powder or cork dust, we shall be able to detect the slightest movement.

On turning on a fairly steady blast of air a circulation at once begins,

Sketch of Working Model of the Gulf Stream.

and in a few moments the whole surface of the model ocean is in movement. These are the two great Equatorial currents, with the return stream between them which hugs the African coast into the Gulf of Guinea. When the South Equatorial impinges on Cape S. Roque it divides, producing the Brazil current to the South, while the other portion joins the North Equatorial. Part of this combined current passes outside the West Indies, but a great deal goes on into the Gulf of Mexico. A return swirl may be noted by Mosquito Bay and the Isthmus of Panama.

As the stream sweeps through the Yucatan Channel it is picked up by the Northerly wind and urged southwards into Campeachy Bay. It then makes the circuit of the Gulf of Mexico, streaming out through the Florida Channel and following a course much like that of the real Gulf Stream.

The tropical waters are brought under the influence of the Anti-trades, and carried by them up to the coast of Norway.

The urging of so much water towards the north causes a return flow down the coast of Greenland and down Davis Strait, while the Northerly wind on the coast of Labrador sets up the return current which flows northwards along the west coast of Greenland.

Owing to the shallowness of the tray there could not be any considerable undercurrent equivalent to a slow set of the cold polar waters southward, and the accumulation of water in the parts representing the Arctic Ocean became so great that the whole working of the model was disturbed. But the construction of a free communication between the top and bottom of the tray, round

behind the block of wood which represents America, completely cured this defect.

A part of Central America from Panama to Vera Cruz is moveable in the model, and if this is taken out it is seen that a large part of the water from the Equatorial currents passes on into the Pacific. The Gulf Stream is greatly lessened, and the water urged to the western shores of Europe is that which has just come down from the Arctic Ocean by the Greenland coasts.

However, I do not imagine that the apparatus in its present condition will be of any value as an instrument of research. I have brought it before the Fellows of this Society in the belief that it will be found useful in the explanation of the phenomena it represents, whether that explanation be offered to children at school or to students of riper years.

Tenth Annual Exhibition of Instruments,

PRINCIPALLY ACTINOMETERS AND SOLAR RADIATION APPARATUS,

Held, by permission of the Council of the Institution of Civil Engineers, at 25 Great George Street, Westminster, S.W.,

MARCH 19TH TO 22ND, 1889.

ACTINOMETERS.

1. **Herschel's Actinometer,** for ascertaining the absolute heating effect of the solar rays, in which time is considered one of the elements of observation. The actinometer consists of a large cylindrical thermometer bulb, with a special open scale, so that minute changes may be easily seen. The bulb is of transparent glass filled with a deep blue liquid, which is expanded when the rays of the sun fall on the bulb. When taking an observation, the actinometer is shaded for one minute and read off; it is then exposed for one minute to sunshine, and its indication recorded; it is finally shaded again, and its reading again noted. The mean of the two readings in the shade, subtracted from that in the sun, indicates the expansion of the liquid produced by the sun's rays in one minute of time. *Exhibited by* THE KEW COMMITTEE.

2. **Hodgkinson's Actinometer.** This instrument consists of a thermometer with a spherical bulb one inch in diameter, and a tube, of which an inch and a half next the bulb is divided. The fluid employed is alcohol coloured with a drop of pure aniline blue. The principle of the instrument is the same as that of Sir J. Herschel's. It was devised for mountain use, where the weight of Herschel's instrument and the fragility of its internal thermometer are elements of difficulty. A plain

telescope tube of bright metal 18 ins. long and 2½ ins. in diameter, open at both ends, is pierced in its central section with a circular hole 1¼ to 1½ in. in diameter, from which springs a flanged shoulder projecting about ½ in. to receive a perforated split bung, which clasps the thermometer stem and holds the bulb firmly in the centre of the axis of the tube. Two caps, fitted with clear plate glass, are made to slide off and on at the two ends to admit of the glasses being readily wiped. (*Proc. Roy. Soc.* Vol. XV. p. 321.) *Exhibited by* THE KEW COMMITTEE.

3. **Pouillet's Direct Pyrheliometer.** This instrument is composed of a cylindrical box of steel filled with mercury. Into the cylinder a thermometer is introduced, the stem of which is protected by a piece of brass tubing. As the surface on which the sun's rays fall and the quantity of mercury in the cylinder are both known, the effect of the sun's heat upon a given area can be expressed by stating that it is competent in five minutes to raise so much mercury so many degrees in temperature. *Exhibited by* THE KEW COMMITTEE.

4. **Improved Form of Pouillet's Pyrheliometer.** The instrument is placed in a silvered tube to shield it from wind and from all solar rays, except when the tube is turned directly towards the sun.

Exhibited by the Rev. F. W. STOW, M.A., F.R.Met.Soc.

5. **Secchi's Solar Intensity Apparatus** for measuring the comparative intensity of the sun's rays. Two thermometers are kept immersed in a fluid at any convenient temperature, and a third, of which the stem passes through the same liquid and the bulb is outside it, is exposed to the rays of the sun shining down the hollow cylinder. The increase of temperature thus obtained is found to be the same independent of the temperature of the fluid which surrounds the thermometer.

Exhibited by L. P. CASELLA, F.R.Met.Soc.

6. **Prof. Balfour Stewart's Actinometer.** This consists of a copper cube 3½ inches square outside, the faces of which are ⅛ inch thick. The cube is packed round with felt, and the whole faced outside with thin polished brass plates. Thermometers are inserted into that side of the cube intended to face the sun, and into the opposite side, by means of which the temperature of these sides can be accurately determined. A thermometer is also placed in the centre of the enclosure, and the sun's rays are admitted to it through a hole.

Exhibited by the BRITISH ASSOCIATION SOLAR RADIATION COMMITTEE.

7. **Angstrom's Pyrheliometer.** This instrument is adapted for making accurate determinations of the solar radiation as well as for determining the constants of some other instruments constructed to measure radiant heat. It is to be used in connection with a sensitive reflecting dead beat galvanometer. For the purpose of showing how the plates of the calorimeter are prepared, only one is entirely finished. The other shows the appearance of the plates after deposition of copper and platina and before blackening by the smoke of a candle. (*Nova Acta Reg. Soc. Sc. Ups.*, Ser. III. 1886.) *Exhibited by* DR. K. ANGSTRÖM.

8. **Crookes' Radiometer.** This instrument consists of four arms of some light material, suspended on a hard steel point, resting in a cup, so that the arms are able to revolve horizontally upon the centre pivot. To the extremity of each arm is fixed a thin disc of light material, white on one side and lamp-blacked on the other, the black surfaces of all the discs facing the same way. The whole is enclosed in a thin glass globe, which is then exhausted to the highest attainable point and hermetically sealed. The arms rotate with more or less velocity under the action of radiation.

Exhibited by J. J. HICKS, F.R.Met.Soc.

9. **Luvini's Dietheroscope** for observing the changes of atmospheric refraction optically. The instrument consists of two convex lenses of the same focal length, placed on the same axis and at a distance apart double of their focal length. Such an arrangement of lenses will present an image reversed in position but unaltered in size. If we observe with a telescope a distant object through the pair of lenses, the image will appear as if the lenses did not exist, but will be reversed. If now the telescope be so placed that its field of view is divided into two parts, for vision through the lenses and through open space respectively, we shall see two images of each object, one reversed with respect to the other. If then any movement of the object takes place either real or apparent, due to refraction, there will be a corresponding movement of the image, and the latter movement will be double of the former. The observation is made as follows :—The dietheroscope is fixed in a certain position, and observations of the relative positions of the two images of the same object are made at regular intervals. These can be used to determine refraction. *Exhibited by the* METEOROLOGICAL COUNCIL.

10. **Bellani's Lucimeter,** as arranged by Prof. G. Cantoni for use at the Italian Meteorological Stations. The instrument consists essentially of two glass bulbs of the same diameter (about 5 c.m.), the upper of black, the lower of clear glass. The distance between them is three times their diameter. The upper parts of the bulbs communicate with each other by a tube conveniently bent. To the bottom of the lower bulb is attached a graduated tube about 4 decimeters in length, of an internal diameter of 5 mm., termed the volumetric tube. A small quantity of distilled water is introduced enough to fill about three-fifths of the black bulb, and the instrument is sealed so as to exclude all air. The observation is made by recording the number of degrees in the volumetric tube filled by water distilled from the black bulb.

Exhibited by the METEOROLOGICAL COUNCIL.

11. **Marriott's Actinometer** (two patterns). This is an instrument for comparing the actinic value of light at different stations. It is composed of a sensitive surface capable of being darkened to a standard tint by the action of light, which is received through a screen varying in density. The light is of greater actinic value according as it can produce the standard tint through a greater density of the screen.

In the second pattern the sensitive surface is placed round a drum which may be moved from the outside. A new surface can therefore be presented to the action of the light for each hour of the day.

Exhibited by A. S. MARRIOTT, F.R.Met.Soc.

12. **Downes' Method of Slow Actinometry by Oxalic Acid.** A definite quantity of a standard of oxalic acid is exposed to the action of light for a definite period. Subsequently it is used to bleach a standard solution of permanganate of potash. The quantity of oxidized oxalic acid solution, compared with the quantity originally required to produce the same effect, is a measure of the intensity of the light.

Exhibited by Dr. A. DOWNES.

SOLAR RADIATION THERMOMETERS.

13. **Black-glass bulb Maximum Thermometer.**

Exhibited by Messrs. NEGRETTI AND ZAMBRA.

14. **Black-bulb Maximum Thermometer** *in vacuo.*

Exhibited by Messrs. NEGRETTI AND ZAMBRA.

15. **Hicks's Black-bulb Maximum Thermometer** *in vacuo*, with platinum wires and battery for testing the vacuum.
Exhibited by J. J. HICKS, F.R.Met.Soc.

16. **Negretti and Zambra's Black-bulb Maximum Thermometer** *in vacuo*, with mercurial gauge for testing the vacuum.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

17. **Hicks's Radio-Solar Thermometer.** This is the ordinary Black-bulb Maximum Thermometer *in vacuo*, but having at the end of the outer jacket a second chamber in which is mounted vertically one of Crookes's radiometers for testing the vacuum. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

18. **Negretti and Zambra's Black-bulb Maximum Thermometer** *in vacuo*, for exposure to the sky in a vertical position. The scale is figured in the opposite way to an ordinary instrument, the reading commencing from the end of the tube and not from the bulb.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

19. **Black-bulb Maximum Lenticular Thermometer** *in vacuo*, with a very small bulb, and having the bore magnified about twelve times in diameter by the tube being lenticular. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

20. **Black-bulb and Bright-bulb Maximum Thermometers** *in vacuo*.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

21. **Black-bulb and Bright-bulb Thermometers** *in vacuo*, mounted in an upright position with the bulbs uppermost. (As used at the Montsouris Observatory, Paris.) *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

22. **Richard's continuously recording Black-bulb and Bright-bulb Solar Radiation Thermometers.** This is a modification of Richard's well-known thermograph, and gives a continuous record of the temperature of a black and a bright-bulb thermometer *in vacuo*.
Exhibited by MM. RICHARD FRÈRES.

(N.B.—This instrument failed to arrive, but an engraving of it was exhibited instead.)

23. **Black-bulb Maximum Thermometer** *in vacuo*, in which the bulb was broken during the hailstorm of August 3rd, 1879, without injury to the outer jacket. *Exhibited by* THE KEW COMMITTEE.

24. **Southall's Helio-Pyrometer** for testing the accumulated heat of the sun in a confined blackened space, under glass. A black-bulb maximum thermometer is fixed on a cushion at the bottom of box, the sides of which are also cushioned, and a thick piece of plate-glass is laid upon the top to prevent currents of air carrying off the heat, also with the view of preventing the cooling effects of terrestrial radiation. The box is placed in such a position that the sun's rays may strike as nearly as possible perpendicularly on the glass. A small vessel is also added, in which water boils violently in the box, a piece of tube carrying off the steam. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

25. **Frankland's Self-registering Differential Solar Thermometer,** for recording the maximum solar intensity (*Proc. Roy. Soc.* Vol. XXXIII., p. 338.) *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

SUNSHINE RECORDERS.

26. **Campbell's Sunshine Bowls** (six), exhibiting the effect of sunshine during the half-years :—June to December, 1855 ; December to June, 1856 ; June to December, 1856 ; June to December, 1883 ; December to June, 1884 ; June to December, 1884.

Exhibited by the METEOROLOGICAL COUNCIL.

27. **Campbell's Sunshine Recorder.** A sphere of glass, 4 inches in diameter, is supported in a hemispherical metal bowl, having engraved azimuth and altitude circles for the proper placing in position of the strip on which the record is made. This instrument was used at the Royal Observatory, Greenwich, from 1876 to 1886.

Exhibited by W. H. M. CHRISTIE, F.R.S., Astronomer-Royal.

28. **Sunshine Recorder** for a fixed latitude, as used by the Meteorological Office. *Exhibited by the* METEOROLOGICAL COUNCIL.

29. **Whipple-Casella Sunshine Recorder.**—The instrument is furnished with divided latitude and declination circles, and thus can be easily set for any locality, and for any day in the year.

Exhibited by L. P. CASELLA, F.R.Met.Soc.

30. **Sunshine Recorder** with adjustments for use in any latitude.

Exhibited by Messrs. NEGRETTI AND ZAMBRA.

31. **Chemical Photometer devised by Sir H. Roscoe, M.P., F.R.S.** This is a simple mode of measuring the chemical action of total daylight, adapted to the purpose of regular meteorological registration. By means of this instrument a strip of paper is so exposed that the different times of chemical action can be calculated to within small fractions of a second. The exposure of the paper is effected by pasting pieces of standard sensitive paper upon a band, and inserting this into a thin metal slide having a small opening at the top furnished with a cover, which can be made instantly to open or close the hole under which the sensitive paper is placed. (First Pattern, 1863.)

Exhibited by THE KEW COMMITTEE.

32. **Experimental Instrument for Recording the Intensity of Daylight,** the results being obtained by revolving a disc of sensitized paper behind a screen with a rectangular aperture. *Exhibited by* J. B. JORDAN.

33. **Jordan's Photographic Sunshine Recorder.** This instrument consists of a cylindrical box, on the inside of which is placed a slip of cyanotype paper. Sunlight being admitted into this chamber by three small apertures, is received on the paper, and travelling over it by reason of the earth's rotation, leaves a distinct trace of chemical action. (*Quarterly Journal Roy. Met. Soc.* Vol. XII. p. 22.)

Exhibited by Messrs. NEGRETTI AND ZAMBRA.

34. **Jordan's Photographic Sunshine Recorder.** Improved pattern. In this pattern two apertures are used instead of three.

Exhibited by Messrs. NEGRETTI AND ZAMBRA.

35. **Jordan's Photographic Sunshine Recorder.** New pattern. The improvement in this instrument over the previous patterns consists in using two semi-cylindrical or D-shaped boxes, one to contain the morning and the other the afternoon record. An aperture for admitting the beam of sunlight is placed in the centre of the rectangular side of each box so that

the length of the beam within the chamber is the radius of the cylindrical surface on which it is projected ; its path therefore follows a straight line on the paper at all seasons of the year. The semi-cylinders are placed with their diametral planes at an angle of 60° to each other. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

36. **Prof. McLeod's Photographic Sunshine Recorder.** This instrument consists of a glass sphere silvered inside and placed before the lens of a camera, the axis of the instrument being placed parallel to the polar axis of the earth. The light from the sun is reflected from the sphere, and some of it passing through the lens forms an image on a piece of prepared paper within the camera. In consequence of the rotation of the earth, the image describes the arc of a circle on the paper, and when the sun is obscured this arc is broken.

Exhibited by J. J. HICKS, F.R.Met.Soc.

NEW INSTRUMENTS.

37. **Negretti and Zambra's Recording Hygrometer.** This consists of a Dry- and a Wet-bulb thermometer (constructed on the principle of Messrs. Negretti and Zambra's Deep Sea registering thermometer) attached to a carrier and actuated by a timepiece of the nature of an alarum clock. This may be set for any hour, and at the proper time it will cause the thermometers to turn upside down, and thus record the temperature at that moment. This instrument has the improved water receptacle arrangement suggested by Mr. Bayard.

Exhibited by Messrs. NEGRETTI AND ZAMBRA.

38. **New Form of Barometer.** This consists of a self-compensating Sympiesometer, from which the temperature scales are entirely eliminated. The Sympiesometer tube (inverted) has beside it a thermometer, carried on a sliding frame, on which the barometrical scale is engraved. The two are so adjusted that they have the same range for temperature, so that when the two liquid surfaces are brought level together they remain so under all changes of temperature as long as the barometric pressure remains unaltered. The barometer reading is shown by a fixed index against the sliding scale. The alteration of pressure is shown by the difference of level. A new reading is taken by bringing them again into level, and the observation remains recorded. Scale four times that of the barometer. *Exhibited by* A. DE NORMANVILLE.

39. **Boylean Mariotte Barometer.** This instrument, which was invented by T. Telford Macneill, consists of a short central glass tube, a lower open-air tube or bulb, with diaphragm joined to it, covered with wood and a brass tube enveloping the glass and on which the scale is engraved. Attached to this is a cistern filled with mercury, which has a stopcock and a screw adjustment. The total length of the instrument is from 12 to 15 ins., but for convenience of carriage the cistern can be detached and carried separately. The atmospheric pressure is measured by an uniform volume of air being admitted to the cistern, and compressed by the advance of the mercury to a fixed point. The readings are taken from two points, as in the Fortin barometer.

Exhibited by L. P. CASELLA, F.R.Met.Soc.

40. **Apparatus for obtaining Readings of an Aneroid** placed at a distance by means of electric currents. *Exhibited by* T. J. MURDAY.

41. **Stephanome.** This instrument is used at the Ben Nevis Observatory for measuring the angular size of halos, fog-bows, glories, &c. The eye is applied to the sight at one end, and the sliding bar moved along the graduated rod until either the outer or inner pair of points on it coincide with the ends of a diameter of the circle being measured. The graduations on the rod are reduced to angular measure and tabulated; measurements can be made to an average accuracy of about 5 minutes of arc. The small disc attached to the rod by a rider is only used to hide the sun or moon when measuring halos or coronæ.
Exhibited by the DIRECTORS OF THE BEN NEVIS OBSERVATORY.

42. **Fineman's Nephoscope.** This is an improvement on Fornioni's Nephodoscope. (*Atti della Prima Riunione Meteorologica Italiano* 1881.) It consists of a black mirror on which are engraved four diameters crossing at an angle of 45°, and two concentric circles; a circle of clear glass is let into the mirror in order to show the point of a magnetised needle playing on a pivot beneath the mirror. Beside the mirror is a scale graduated in millimetres, moveable in a vertical direction by a rack and pinion. The point of this scale is set to such a height that looking over it the image of a point of a cloud can be seen reflected in the centre of the mirror, and the concentric circles are intended to give definite distances by which to measure the movement of the cloud point in direction and velocity by the displacement of its image.
Exhibited by the METEOROLOGICAL COUNCIL.

43. **Galton's Nephoscope.** This consists of a horizontal mirror placed inside a circle marked with the eight points of the compass. The mirror revolves freely. Above it is placed a vertical grating, with horizontal bars, which is fixed to the mirror, and can be set in any azimuth, so as to coincide with the direction of motion of a cloud observed in the mirror, which direction is read off on the graduated circle. The mirror is intended for the observation of clouds from the zenith to about 50°. The grating for those from 50° to 20° in altitude. The apparatus is fitted with a travelling sightpiece on an arm for observations of slow moving clouds at low elevations.
Exhibited by the METEOROLOGICAL COUNCIL.

44. **Air Meter or Biram Anemometer,** reading to 1,000 feet, with Minute glass attached. *Exhibited by* Messrs. JOHN DAVIS AND SON.

45. **Davis's Self-Timing Air Meter,** with improved mechanism. The index reverts to zero after each observation, and the instrument requires no calculation whatever for corrections, or for the position of the index hands at starting, and indicates feet per second.
Exhibited by Messrs. JOHN DAVIS AND SON.

46. **Davis's High-Speed Air Meter,** without vanes, reading to 10 million feet, constructed for high velocities.
Exhibited by Messrs. JOHN DAVIS AND SON.

MODELS.

47. **Working Model illustrating the generation of Ocean Currents.**
Exhibited by A. W. CLAYDEN, M.A., F.R.Met.Soc.

48. **Models of Hailstones,** 7 inches in circumference, which fell near Montereau, France, on August 15th, 1888. (See *Quarterly Journal of the Royal Meteorological Society*, Vol. XV. p. 47.) *Exhibited by* A. C. STRATTEN.

PHOTOGRAPHS, DRAWINGS, &c.

49. **Engraving of Violle's Actinometer.** The bulb of a thermometer previously blackened by smoke is exposed to the sun at the centre of a spherical copper enclosure, blackened inside, the rays penetrating by a tubular opening. This enclosure, surrounded by an outer envelope polished on its exterior surface, is kept at a constant temperature by a current of cold water or by pounded ice.

Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

50. **Engraving of Frohlich's Actinometer.** (*Zeitschrift der oesterreichischen Gesellschaft für Meteorologie*, Band XIX. p. 214.)

Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

51. **Engraving of Crova's Recording Actinometer.** *Exhibited by* A. CROVA.

52. **Photograph of Angstrom's Pyrheliometer.** *Exhibited by* Dr. K. ANGSTRÖM.

53. **Engraving and Description of Draper's Self-Recording Sun Thermometer,** as in use at the New York Meteorological Observatory.

Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

54. **Graphic Record of Sunshine at the Royal Botanic Gardens, Regent's Park, 1886 to 1888.** *Exhibited by the* ROYAL BOTANIC SOCIETY.

55. **Sunshine Cards for July 1887 recorded at the Royal Botanic Gardens, Regent's Park.** *Exhibited by the* ROYAL BOTANIC SOCIETY.

56. **Drawings and description of Favre's Meteorograph,** which records the indications of the barometer, thermometer, hygrometer, and direction and force of the wind at a distance. *Exhibited by* C. A. FAVRE.

57. **Photographs of Flashes of Lightning** sent to the Royal Meteorological Society since May 1888 by :—

Mr. R. C. Bayley, Peterborough.
Mr. A. H. Binden, Wakefield, Mass., U.S.A.
Mr. H. Butler, Vermilion, Dak., U.S.A.
Mr. H. P. Curtis, Boston, Mass., U.S.A.
Rev. C. H. Griffith, Strathfield Turgiss.
Herr R. Haensel, Reichenberg, Bohemia.
Mr. M. I'Anson, Newark, New Jersey, U.S.A.
Mr. A. W. Nicholls, Peterborough.
Mr. H. C. Russell, F.R.S., Sydney, N.S.W.
Mons. E. L. Trouvelot, Meudon, near Paris.
Mr E. E. Van Epps, Oberlin, Kas., U.S.A.

58. **Engraving showing Clothing destroyed by Lightning.**

Exhibited by THE ROYAL METEOROLOGICAL SOCIETY.

59. **Photographs of Electric Spark** taken while the sensitive plate was rotating 2,500 times per minute.

Exhibited by J. WIMSHURST.

60. **Lantern Slides illustrating the spiral circulation of the wind** in high and low pressure areas.

Exhibited by A. W. CLAYDEN, M.A., F.R.Met.Soc.

61. **Photographs of Clouds** taken in Southern Brazil, 1888.
Exhibited by E. S. SHEPHERD.

62. **Photographs of Cumulus and Stratus Clouds.**
Exhibited by CAPT. D. WILSON-BARKER, F.R.Met.Soc.

63. **Photograph of apparatus used at the Kew Observatory for determining the height and motion of Clouds** from photographs; designed and constructed by Mr. G. M. Whipple, F.R.Met.Soc.
Exhibited by THE METEOROLOGICAL COUNCIL.

64. **Photograph of Whirler for testing Air Meters at the Kew Observatory.** *Exhibited by* THE KEW COMMITTEE.

65. **Photograph of the Thermometer Screens at the Royal Observatory, Greenwich.**
Exhibited by W. H. M. CHRISTIE, F.R.S., Astronomer-Royal.

66. **Photographs taken on the summit of Ben Nevis** during the last eleven months. *Exhibited by the* DIRECTORS OF THE BEN NEVIS OBSERVATORY.

67. **Two Photographs** showing (1) the New Suspension Bridge with the Falls of Niagara beyond, and the "Maid of the Mist," taken before the tornado of January 9th, 1889; and (2) the roadway of the bridge at the American end destroyed by the tornado.
Exhibited by C. J. BROMHEAD, F.R.Met.Soc.

68. **Two Large Photographs showing the thick rime on trees** at Lincoln on January 7th, 1889. *Exhibited by* C. J. BROMHEAD, F.R.Met.Soc.

69. **Photograph taken by Moonlight.** *Exhibited by* H. P. CURTIS.

70. **Diagrams illustrative of the comparative yearly Rainfall of the Globe, 1838-1887.** *Exhibited by* W. B. TRIPP, F.R.Met.Soc.

71. **Meteorological Chart** for use at Second Order Stations, arranged to contain the monthly means for a year.
Exhibited by Capt. D. WILSON-BARKER, F.R.Met.Soc.

WILLIAM MARCET, M.D., F.R.S., *President.*

G. J. SYMONS, F.R.S.
JOHN W. TRIPE, M.D. } *Secretaries.*

WILLIAM MARRIOTT, *Assistant Secretary.*

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

MARCH 20TH, 1889.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

ALFRED JOHN HANDS, St. Ronan's, Fairholt Road, Stamford Hill, N.;
JAMES JACKSON, 27 Albion Grove, Barnsbury;
STEPHEN ADOLPHUS JONES, 19 Ludgate Hill, E.C.;
JOHN EDWARD MIDDLEHURST, Springwood Hall, Pendlebury, Manchester; and
LEONARD SUTTON, F.R.G.S., Cintra Lodge, Reading,
were balloted for and duly elected Fellows of the Society.

The following Paper was read:—

"THE SUN, ITS HEAT AND LIGHT." By WILLIAM MARCET, M.D., F.R.S., President. (p. 127.)

On the motion of Mr. INWARDS, seconded by Mr. BREWIN, the thanks of the Society were given to the Exhibitors for the loan of their instruments, &c.

The meeting was then adjourned in order to afford the Fellows an opportunity of inspecting the Exhibition of Instruments, principally Actinometers and Solar Radiation Apparatus, which had been arranged in the rooms of the Institution of Civil Engineers. The List of Exhibits will be found on p. 166.

APRIL 17TH, 1889.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

ROBERT COCKBURN MOSSMAN, 10 Blacket Place, Edinburgh; and
EDWARD HERON RYAN-TENISON, M.R.C.S., Kilronan, Upper Station Road, Bexhill-on-Sea,
were balloted for and duly elected Fellows of the Society.

The following Papers were read:—

"ON THE RIME-FROST OF JANUARY 6TH AND 7TH, 1889." By C. B. PLOWRIGHT, F.L.S. (p. 137.)

"ON THE DEATHS CAUSED BY LIGHTNING IN ENGLAND AND WALES FROM 1852 TO 1880. By ROBERT LAWSON, LL.D., F.R.Met.Soc. (p. 140.)

"THE DIURNAL RANGE OF THE BAROMETER IN GREAT BRITAIN AND IRELAND." By F. C. BAYARD, LL.M., F.R.Met.Soc. (p. 146.)

"NOTE ON A WORKING MODEL OF THE GULF STREAM." By A. W. CLAYDEN, M.A., F.R.Met.Soc. (p. 164.)

CORRESPONDENCE AND NOTES.

Instructions for taking Photographs of Lightning. By William Marriott, F.R.Met.Soc.

At the Meeting of the Photographic Club on July 10th, I was requested to draw up some instructions for taking photographs of Lightning, so that photographers, professional as well as amateur, might, in the event of a thunderstorm, be prepared to obtain some really good photographs.

If the following brief instructions be complied with, the photographs of lightning will possess scientific value :—

1. The camera should be focussed during the daytime to some distant object, and a mark made on the camera, so that at night it may be quickly adjusted when a storm is approaching.
2. A rapid rectilinear lens, with full aperture, should be used.
3. The camera should be directed to the part of the sky where the lightning is most likely to occur.
4. The camera should be firmly screwed to the tripod stand.
5. It may be necessary to tilt the camera slightly, especially if the lightning be mostly in the zenith. If this be done, a note should be made of the amount of inclination.
6. A portion of landscape, roof, chimney-pot, &c. should, if possible, be included on the plate. If this cannot be done, the top of the plate should be carefully marked before it is removed from the dark slide.
7. The exact time of each flash, the interval in seconds between the lightning and the thunder, and the point of the compass in which the flash appeared, should all be carefully recorded.
8. It is desirable that there should be only one flash upon each plate.
9. If circumstances permit, two cameras should be used—one fixed on the tripod stand and the other held in the hand,—and two separate photographs obtained of the same flash.
10. It would be very interesting and valuable if two or more photographers could obtain pictures of the same flash from different points of view. By this means it might be possible to determine accurately the distance of the flash and also its movements in the atmosphere.

The Royal Meteorological Society will be glad to receive copies of all photographs of lightning that may be taken,—even apparently poor ones often contain useful evidence.

Experiments with Solar Radiation Thermometers. By T. G. Benn, F.R.Met.Soc.

For a period of 142 days from February 16th to July 7th, 1887, I carried on an experiment with three Solar Radiation Thermometers, the instruments used being K.O. 14865 ; K.O. 14531 ; and K.O. 20089.

The first named (K.O. 14865) is the instrument in constant use at this station ; and K.O. 20089 is fitted with Negretti and Zambra's vacuum test gauge. The whole of the thermometers were made by this firm.

The instruments were exposed on a post at a height of 4 feet above grass with their spheres pointing to the south-east and 4 inches apart. They were read daily at 9 p.m. during the period of the experiment. The means of the 142 readings were :—

K.O. 14865	K.O. 14531	K.O. 20089
102°·8	102°·9	103°·2

a very close agreement, but on individual occasions there were great differences, as will be seen below.

The maximum shade temperature and the duration of bright sunshine are given for the days on which the greatest differences were observed.

1887.	K.O. 14865	K.O. 14531	K.O. 20089	Max. Shade Temp.	Hours of Bright Sunshine.
	°	°	°	°	
Feb. 27	95·2	90·5	90·7	53·0	7·2
Mar. 15	116·5	115·2	108·0	35·2	4·5
„ 16	87·0	97·0	101·0	38·0	6·7
April 23	100·2	110·0	109·8	52·7	6·0
„ 25	87·8	85·8	84·2	46·3	6·7
May 1	100·5	102·1	103·6	52·0	4·3
„ 13	82·5	87·2	86·0	47·4	5·0
„ 24	102·4	102·5	113·0	62·0	0·4
June 17	113·0	116·8	117·2	77·0	2·0
„ 25	127·2	136·0	136·1	80·0	14·5
„ 29	130·0	131·0	134·0	75·2	10·0

The above are the greatest differences, but on many occasions the readings disagreed by about 3°. On only 21 days did any two of the instruments read exactly alike; and March 27th, June 1st, 8th, and 30th were the only days on which the readings of the three thermometers were identical, the values being respectively 98°·0; 122°·0; 118°·0; and 118°·0.

On March 15th K.O. 20089 was lowest by 8°·5, on the following day the same thermometer read highest by 14°·0, although the shade temperature was only 2°·8 higher. Again on May 24th this thermometer registered 10°·6 higher than K.O. 14865, although there was less than half an hour of bright sunshine. K.O. 14531 and K.O. 20089 agreed very nearly on June 25th, when there was a large amount of sunshine, while the thermometer in regular use was nearly 9° lower.

GROSSMANN'S "CONTRIBUTION TO THE HISTORY AND THEORY OF THE PSYCHROMETER."[1] Kindly communicated by W. N. SHAW, M.A.

IN the historical introduction a sketch of the development of the theory of the wet-bulb thermometer is given. Though no exact psychrometric formula has hitherto been obtained, some progress has recently been made in the subject. Ferrel,[2] by a modification of the Stefan[3]-Maxwell[4] formula, has deduced an expression for the case of air in motion; and the investigations of Nils Ekholm[5] have thrown further light upon the not infrequent case of the wet-bulb, in frost, reading higher than the dry.

1. If a wet-bulb exposed in air (pressure B, vapour-pressure p, and temperature t) reads t_1 in consequence of the evaporation of water (the latent heat being λ), and if p_1 be the pressure of saturated vapour at t_1, we may assume that, when the conditions have become steady, the process which has gone on and is going on continuously round the wet-bulb is as follows:—A quantity of heat is absorbed by evaporation, the vapour-pressure of a layer of air containing m_1 grammes of dry air being raised from p to p_1; this heat is supplied by the reduction of the temperature of a layer of air, containing m^1 grammes of dry air, from t to t_1.

Equating these quantities of heat, we get, if S be the specific heat of dry air, S_1 the specific heat of moist air referred to unit mass of dry air, σ the specific gravity of vapour referred to air at the same temperature and pressure,

$$p = p_1 - \frac{BS}{\sigma\lambda}(t - t_1)\left[\frac{B - p_1}{B} \cdot \frac{S_1}{S}\frac{m}{m_1}\right] \quad \ldots \quad \ldots \quad 1\,(a).$$

a general and strict formula for the psychrometer under the conditions. This reduces to August's formula on introducing the assumption that the whole of the air which is reduced in temperature, becomes at the same time saturated by the evaporation, in other words, that $m_1 = m^1$.

2. The heat derived from the cooling of m^1 is assumed to represent all the heat derived from conduction, radiation, local convection, and the independent

[1] *Meteorologische Zeitschrift*, April and May 1889.
[2] *Annual Report of the Chief Signal Officer of the Army*, Part II. for the year 1885. Ferrel: Recent Advances in Meteorology.
[3] *Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie*. B. XVI. 1881, p. 177.
[4] *Ency. Brit.* Vol. VII. 1877. Art. "Diffusion."
[5] Ekholm: *Undersökningar i Hygrometri*. Upsala, 1888.

general motion of the air. By reckoning separately that part of the heat supplied to the bulb by radiation in time Z as equal to $ZOR\ (t-t_1)$ (O being the area of the surface of the bulb, and R the coefficient of radiation), we get—

$$p = p_1 - \frac{SB}{\lambda\sigma}\ (t-t_1)\left(\frac{q^1}{q_1} + \frac{RO}{q_1 S_1}\right)\left[\frac{B-p_1}{B}\frac{S_1}{S}\right] \quad \ldots \quad \ldots \quad (3)$$

$$\text{where } q^1 = \frac{m^1}{Z},\ q_1 = \frac{m_1}{Z}$$

In order to express the effect of the velocity of motion of the air, assume that q_1 and q^1 are linear functions of the velocity v with a coefficient ε, that they are equal when v is infinite, and that their values, when v is zero, are $q_1{}^\circ$ and $q^1{}_\circ$ respectively.

Substituting, we get the following general formula for the psychrometer, in moving air, with spherical bulb, radius r—

$$p = p_1 - \frac{SB}{\lambda\sigma}\ (t-t_1)\left(\frac{B-p_1}{B}\frac{S_1}{S}\right)\frac{\mathfrak{A}+\mathfrak{B}v}{1+\mathfrak{B}v} \quad \ldots \quad (5)$$

$$\text{where } \mathfrak{A} = \frac{q^1{}_\circ + \frac{4\pi R}{S}\,r\,\frac{S}{S_1}}{q_1{}^\circ};\ \mathfrak{B} = \frac{\varepsilon}{q_1{}^\circ}$$

The values of S, λ, σ, and R are known, and can be substituted—

($\lambda = 606{\cdot}5 - 0{\cdot}695\ t$, for water-covered bulbs $= 685{\cdot}5 - 0{\cdot}695\ t$, for ice-covered bulbs.)

The values of $q_1{}^\circ$ and $q^1{}_\circ$ are not known *à priori*, but they may be regarded as constant for a given velocity, so $\mathfrak{A}$ and $\mathfrak{B}$ can be determined from observations with the psychrometer upon air of known humidity moving with known velocity, and thus a numerical formula of reduction obtained. It is assumed that the radiation effect is the same in moving air as in still air.

3. In the special case of still air, the quantity of heat supplied by conduction can be calculated for spherical bulbs after the manner of Stefan and Ekholm in terms of the temperatures of the bulb and the surrounding air, a coefficient K^1 of conductivity, and a new constant β, viz. the thickness of the spherical layer within which (in the steady state) the wet-bulb produces any depression of temperature. By a similar calculation the quantity of water vaporised for given temperatures can be expressed in terms of a coefficient of diffusion, D, and another new constant β_1, viz. the thickness of the layer within which, in the steady state, the evaporated moisture is diffused. In this way values for q_1 and q^1 are obtained, which lead to an equation, applicable to still air, in which account is taken of the radiation, conduction, and convection of heat, and the diffusion of vapour.

4. From this general equation the formulæ hitherto employed can be deduced by the introduction of the special assumptions upon which they are respectively based. To obtain August's formula (corrected for radiation) K^1 must be put equal to D, and β equal to β_1. In Maxwell's formula β and β_1 are both infinite.

Ferrel's formula for moving air, previously referred to, is obtained by altering the expression for radiation so as to make it follow Dulong and Petit's law, and assuming β to be equal to β_1, and each to be inversely proportional to the velocity of the air. Though the theoretical expressions for $\mathfrak{A}$ and $\mathfrak{B}$ are different, the resulting formula is identical *in form* with (5), except that the factor $\frac{B-p_1}{B}\frac{S_1}{S}$ is omitted. A numerical table shows the effect and importance of the missing factor, which is moreover shown to be required by some observations of Ferrel's, from which it appears that the factor A of the temperature-difference in the typical psychrometer formula, $p = p_1 - AB\ (t-t_1)$,—where A is supposed to have a known value in making reductions—increases more rapidly with the temperature of the wet-bulb than can be accounted for by the mere variation of the latent heat.

5. The general formula (5) is applied to the recalculation of Sworykin's[1] comparison of the psychrometer with the volume-hygrometer and Alluard's dew-point hygrometer, and the results show more satisfactory agreement than that obtained by Sworykin with his three-constant formula— $A = \zeta + \frac{\eta}{\sqrt{v}} + \frac{\zeta}{v}$

[1] Sworykin: Die Bestimmung der Feuchtigkeit der Luft mit dem Psychrometer. *Wild's Repertorium*, VII. 1881.

6. The values of A (for $t_1 = o$) are also tabulated, for a series of velocities; they show considerable variation for small velocities, and also greater variation with a large bulb than with a small one. On this account it is evidently necessary to provide for a constant ventilation of a psychrometer, and to determine the factor A for the specific arrangement of the psychrometer, by comparison with a dew-point instrument. For small velocities the constants for each psychrometer must be determined as far as possible under the conditions that will obtain when the instrument is subsequently used for observations.

7. The carrying out of still further experiments like those of Sworykin, and further observations with the sling hygrometer, appear to be of great value with a view to closer knowledge of certain disturbing causes. An investigation as to whether the quantity A would have a constant value for each psychrometer, if the ventilation were accomplished by fanning the psychrometer according to definite and easily workable instructions, must be regarded as very desirable, because this method appears to be most easily capable of being generally practised.

8. The use of psychrometer tables, founded upon Regnault's formula, certainly gives on the average, for psychrometers with small bulbs, too small values for the humidity.

9. The question as to whether different values for the latent heat of vaporisation should be substituted in formulæ for water-covered bulbs and ice-covered bulbs respectively, was raised by Sworykin upon his finding, in the comparisons before mentioned, that the formula for water-covered bulbs gave satisfactory reductions when applied to ice-covered bulbs. It is pointed out (following Ekholm) that practical importance is to be attached to the fact that below the freezing-point the pressure of water-vapour has one value over ice, and another over water at the same temperature.[1] The latter is the greater and should be taken in dew-point experiments, whereas Regnault's table (used by Sworykin in the comparison) gives the ice-vapour pressure. When account is taken of this, it is shown that Sworykin's observations do not entitle us to abandon the change in the value of λ for ice-covered bulbs, which is required on theoretical grounds.

RECENT PUBLICATIONS.

American Meteorological Journal. May and June 1889. Vol. VI. Nos. 1-2. 8vo. 1889.

The principal articles are:—Meeting of the New England Meteorological Society, April 16th, 1889 (7 pp.). This contains an abstract of the papers read at that Meeting.—Anemometer Comparisons, by Prof. H. A. Hazen (5 pp.).—Tornado Charts of Illinois and Michigan, by Lieut. J. P. Finley (10 pp.).—Verifications at the Signal Office, by M. W. Harrington (14 pp.).—The organisation of the Meteorological Service in some of the principal countries of Europe, by A. L. Rotch (12 pp.). In this paper the author gives an account of the meteorological system in Belgium.—A review of some important Tornado Literature, by F. Waldo (17 pp.). This is a summary of tornado literature and of the various theories propounded for these phenomena.—The Whirlpool Theory of Storms, by M. W. Harrington (6 pp.). This is a summary of Faye's views on the origin of cyclones.—The measurement of Wind Velocity, by W. H. Dines (2 pp.).

Annals of the Astronomical Observatory of Harvard College. Vol. XX. Part 1. 4to. 1889.

This part comprises "Observations made at the Blue Hill Observatory, Massachusetts, U.S.A., in the year 1887." Mr. A. L. Rotch, the founder and proprietor, gives a description of the Observatory and its work. The Observatory is 635 feet above sea level. In addition to the tables of monthly means and totals, the hourly values of atmospheric pressure, temperature, wind

[1] Ekholm has applied this consideration to the explanation of the reading of the wet-bulb being above that of the dry in frost. (*Met. Zeitschr.* V. 1888, p. 64.)

direction and movement, precipitation, cloud and sunshine are also printed in full. The Appendix contains comparisons of the thermometer shelters, and an investigation of the normal differences, and also of marked inversions of temperature between the base and summit.

GEOGRAPHISCHES JAHRBUCH. Vol. XIII. 8vo. 1889.

Contains:—Bericht über die Fortschritte der geographischen Meteorologie, von Dr. J. Hann (74 pp.). This contains a notice of every work or paper of any value which has appeared on Climatology in any part of the world during the three years 1886-1888.

KNOWLEDGE. An Illustrated Magazine of Science. June and July 1889. Vol. XII. Nos. 44 and 45. 4to.

These Nos. contain two interesting papers on Photographs of Lightning, by Mr. A. C. Ranyard and Mr. W. Marriott, which are illustrated by a considerable number of reproductions of photographs of lightning.

METEOROLOGISCHE ZEITSCHRIFT. Redigirt von Dr. J. HANN und Dr. W. KÖPPEN. April-June 1889. 4to.

Contains:—Beitrag zur Geschichte und Theorie des Psychrometers, von Dr. Grossmann (22 pp.). This is a historical research into the use of the dry and wet bulb hygrometer. The conclusions we give elsewhere (see p. 177).—Lephay's Messungen der Intensität der Sonnenstrahlung am Cap Horn, von Dr. J. M. Pernter (6 pp.). This is a review of this section of the report of the French Expedition to Orange Bay. The observations were all carried out by means of a Pouillet's Pyrheliometer.—Die Temperaturverhältnisse der Grotten von St. Canzian bei Triest, von A. Penck (4 pp.). The province of Carniola is full of caves, and the author has carried out the troublesome and dangerous task of exploring some and making observations. He distinguishes three classes of caves: 1. Closed above, difficult of access, and constantly warm; 2. Open above, damp, containing ice, and constantly cold; and 3. Open on each side, with streams flowing through, exposed to great variations of temperature.—Karl Prohaska's Untersuchungen über die Gewittererscheinungen in Steiermark, Kärnten und Oberkrain, von Dr. J. Hann (8 pp.). This is a discussion of thunderstorms in the above-named provinces of Austria.—Zur Thermodynamik der Atmosphäre, von W. von Bezold (8 pp.). This is a condensed account of the author's longer paper in the *Sitzungsberichte* of the Berlin Academy.—Die meteorologischen Beobachtungen des Prof. A. Ackermann in Port au Prince, Haiti, 1864-68, von Dr. J. Hann (7 pp.). It has been known for some years that careful observations were once taken at Port au Prince, where now Prof. Bénard has again undertaken the duty of recording the climate of that semi-barbarous town. Prof. Scherer, a colleague of Prof. Bénard, has at last succeeded in finding in a file of a newspaper some of Prof. Ackermann's results. His original papers were burnt in an insurrection, and the copies Prof. Scherer used were only saved from a similar fate in another insurrection by being in his hands and not in the hands of their rightful owner, who, being a respectable Haytian, was marked out for vengeance by the insurgents, and whose house was burnt.—Ueber die feuchten Funkenröhren und die Gewitterblitze, von Dr. von Lepel (5 pp.). This is an investigation into the different classes of lightning flashes, by passing sparks along a tube covered inside with a film of paraffin and containing a little water. He comes to the following conclusions:—1. There are different kinds of discharges characterised by colour and the noise which accompany them; 2. So-called sheet lightning is due to discharges behind clouds; 3. The most intense flashes are the bright ones (white or pale); 4. The pale bright flashes are probably delayed by resistance, and very liable to set fire to objects; and 5. Rose coloured flashes are weak discharges.

REPORT OF THE FIFTY-EIGHTH MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, HELD AT BATH, IN SEPTEMBER 1888. 8vo. 1082 pp. 1889.

Among the Reports and Papers read were the following:—Third Report of the Committee appointed to cooperate with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis (6 pp.).—Modern views

about hurricanes as compared with the older theories, by the Hon. R. Abercromby (2 pp.).—Report of the Committee appointed to arrange an investigation of the seasonal variations of temperature in lakes, rivers and estuaries in various parts of the United Kingdom (2 pp.).—On the temperature of some Scottish rivers, by H. R. Mill, D.Sc.—On reading electrically meteorological instruments distant from the observer, by J. Joly.—On some accurate charts of Kew corrections for mercury thermometers, by W. N. Shaw.—On an apparatus for determining temperature by the variation of electrical resistance, by W. N. Shaw.—Discussion on Lightning Conductors (24 pp.).—Fourteenth Report on the circulation of underground waters.—On the replenishment of the underground waters of the permeable formations of England, by J. B. Denton (2 pp.).—The Severn Watershed, by J. W. Willis Bund (5 pp.).

REPORT ON THE METEOROLOGY OF INDIA IN 1887. By JOHN ELIOT, M.A., Officiating Meteorological Reporter to the Government of India. Thirteenth Year. 4to. 1889. 610 pp. and 5 plates.

In the Summary Mr. Eliot points out the chief relations holding between the pressure anomalies at the commencement of the South-west monsoon and the distribution of the monsoon rainfall. He says: "It has been shown that the larger pressure anomalies established and intensified during the hot weather were maintained and continued until nearly the end of the rains, when a large and rapid change occurred. It is hardly too much to say that one of the most important and striking features in Indian meteorology is the remarkable persistency of the barometric variations or pressure anomalies. They are generally small in amount, but their duration amidst all the large changes of weather in India indicates most clearly that they represent real and important variations of conditions, more especially of the direction, extent, and intensity of the atmospheric currents prevailing in India. The persistency of the pressure anomalies is almost certainly due to the fact that an abnormal variation of pressure in a moving mass of air necessarily gives rise to, or accompanies, a modification of its motion, and, in consequence of well-known properties of fluid motion, this changed or modified air motion tends to perpetuate, rather than to remove, the pressure variation or disturbance which gave rise to it. And in the case of the atmosphere, the modified air motion also gives rise to variations in the distribution of the rainfall which exert a powerful influence in continuing and increasing the previous pressure conditions and anomalies, so long as the rainfall lasts.

"Experience (confirmed to some extent by theory) hence appears to have established:—1st. That in India the larger and more important variations of atmospheric conditions are remarkably persistent. 2nd. That these abnormal conditions imply more or less prolonged variations in the air motion; and that on the whole the most satisfactory method of ascertaining these areas of abnormal conditions is by means of the pressure anomalies. 3rd. That the larger pressure anomalies are chiefly due to hot weather actions, but also in part to the amount and distribution of the winter snow-fall in the Himalayan region. 4th. That an important after-effect of prolonged rainfall is to smooth away or reverse the pressure anomalies existing previously to the rainfall. 5th. That the pressure anomalies established in April and May modify the direction and strength of the monsoon currents when they set in at the end of May or beginning of June, and thus exercise a very important influence in determining the distribution of the subsequent South-west monsoon rainfall. Hence they may be utilised to give a more or less accurate view of the general distribution of the rainfall of the subsequent South-west monsoon period."

SIXTEENTH ANNUAL REPORT OF THE SECRETARY OF THE STATE BOARD OF HEALTH OF THE STATE OF MICHIGAN for the Fiscal Year ending June 30, 1889. 8vo. 1889. 888 pp.

This contains among other information, papers by Dr. H. B. Baker on the following:—1. Principal meteorological conditions in Michigan in 1887 (77 pp.); 2. The time of greatest prevalence of each disease (64 pp.),—this is a contribution to the causes of sickness· 3 Relations of certain meteorological conditions

to diseases of the lungs and air passages, as shown by statistical and other evidence (27 pp.). The facts collected by the author seem to show that influenza, tonsilitis, bronchitis, and pneumonia have one controlling cause, viz. the inhalation of cold dry air.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. Vol. XXX. Nos. 280-281. May and June 1889. 8vo.

The principal articles are:—Meteorological Bibliography (2 pp.).—Mr. Whipple on Lightning Photographs (2 pp.). This is a report of a paper which was read at a recent Meeting of the Physical Society.—The New England Meteorological Society (3 pp.). This is an account of the Exhibition of Instruments which was held by that Society at Boston from January 15th to 22nd.—The Thunderstorms of May and June (2 pp.).—Earthquake Shock, May 30th, 1889 (2 pp.).—A Cold Period (2 pp.).

THE SCOTTISH GEOGRAPHICAL MAGAZINE. Vol. V. No. 5. May 1889. 8vo.

In a paper on "Samoa," by Dr. G. A. Turner, the author gives the following account of the climate:—"The climate of Samoa is fairly good. The average temperature at midday, taken inside a well-ventilated stone house, is 86°; it never rises above 93°, and it never falls below 80°. At night it is not much cooler. July, August, and September are the coolest months in the year, and February the hottest. During the greater part of the year a fresh Trade wind, which veers from South-south-east to North-east, is constantly blowing, and makes the temperature bearable. The most trying season is from November to February, when often there are days together of still, sultry, oppressive weather. Between the months of December and April long-continued and heavy rains are frequent, attended at times with high winds and northerly gales. Occasionally, too, destructive hurricanes occur. They are not so frequent in Samoa, however, as they are a little further south. Hardly a year passes without one of these gales, of more or less severity, passing over some part of the belt between 10° and 20° south latitude.

VERHANDLUNG DER NATURFORSCHENDEN GESELLSCHAFT ZU BASEL. Teil VIII. 8vo. 1889.

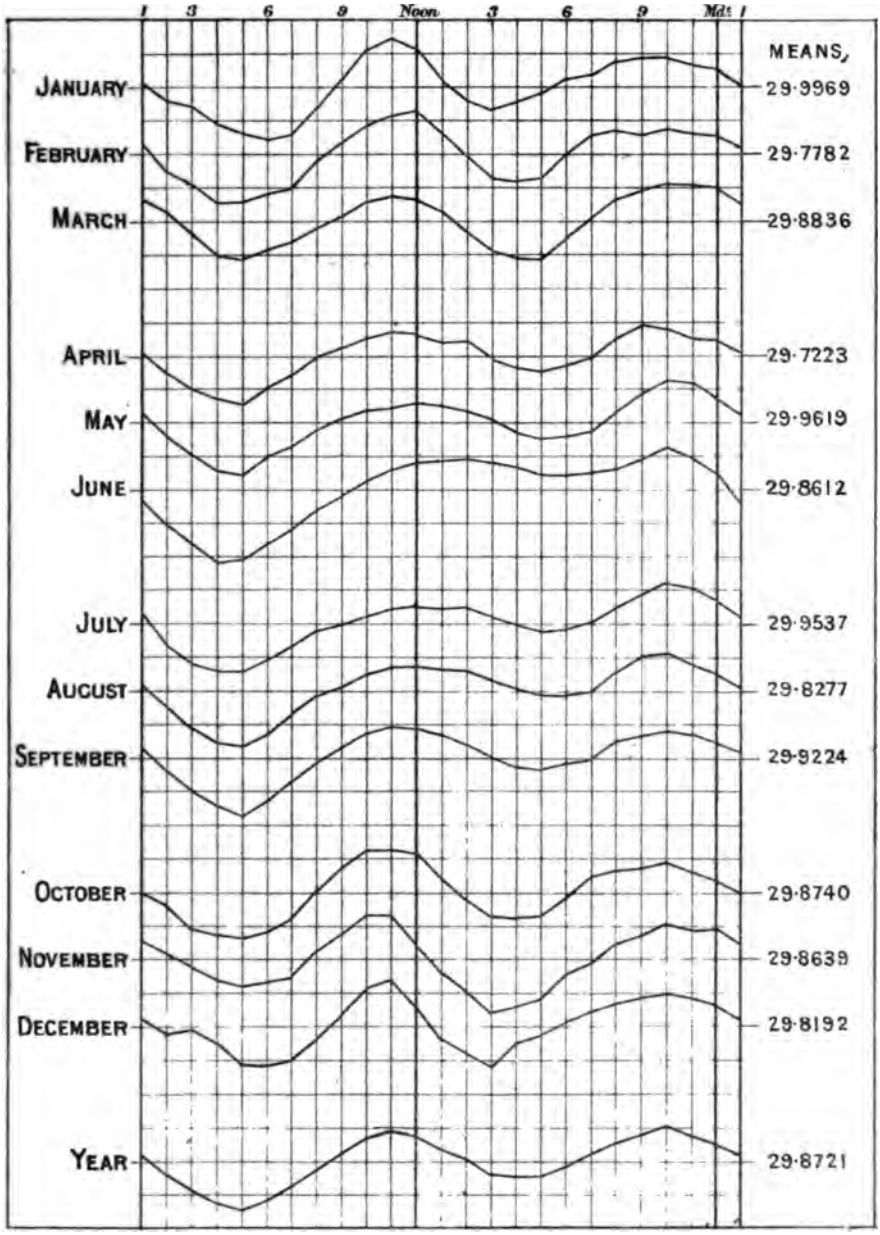
Contains: Resultate aus 112-jährigen Gewitteraufzeichnungen in Basel, von Dr. A. Riggenbach (19 pp.). This is a discussion of 112 years' (1755-1803 and 1826-88) observations of thunderstorms at Basel. Thunderstorms are most frequent during the months of June and July, the time of the maximum occurrence being between 3 and 4 p.m.

WIENER KLEINER WOCHENSCHRIFT. 1889. Nr. 18-19. 8vo.

Contains:—Ueber die Luftfeuchtigkeit als klimatischer Factor, von Dr. J. Hann (13 pp.). The author discusses the relative advantages presented by the representation of hygrometric data, either as vapour tension, relative humidity, or as the deficit of saturation (*i.e.* the difference between saturation and relative humidity). He points out how none of these modes of representation are completely satisfactory, and urges that the influence of deficit of saturation on health be investigated by physicians, but that on no account should the figures for relative humidity be omitted in meteorological tables.

MEAN DIURNAL VARIATION OF THE BAROMETER AT VALENCIA 1876-1880.

Greenwich Time.

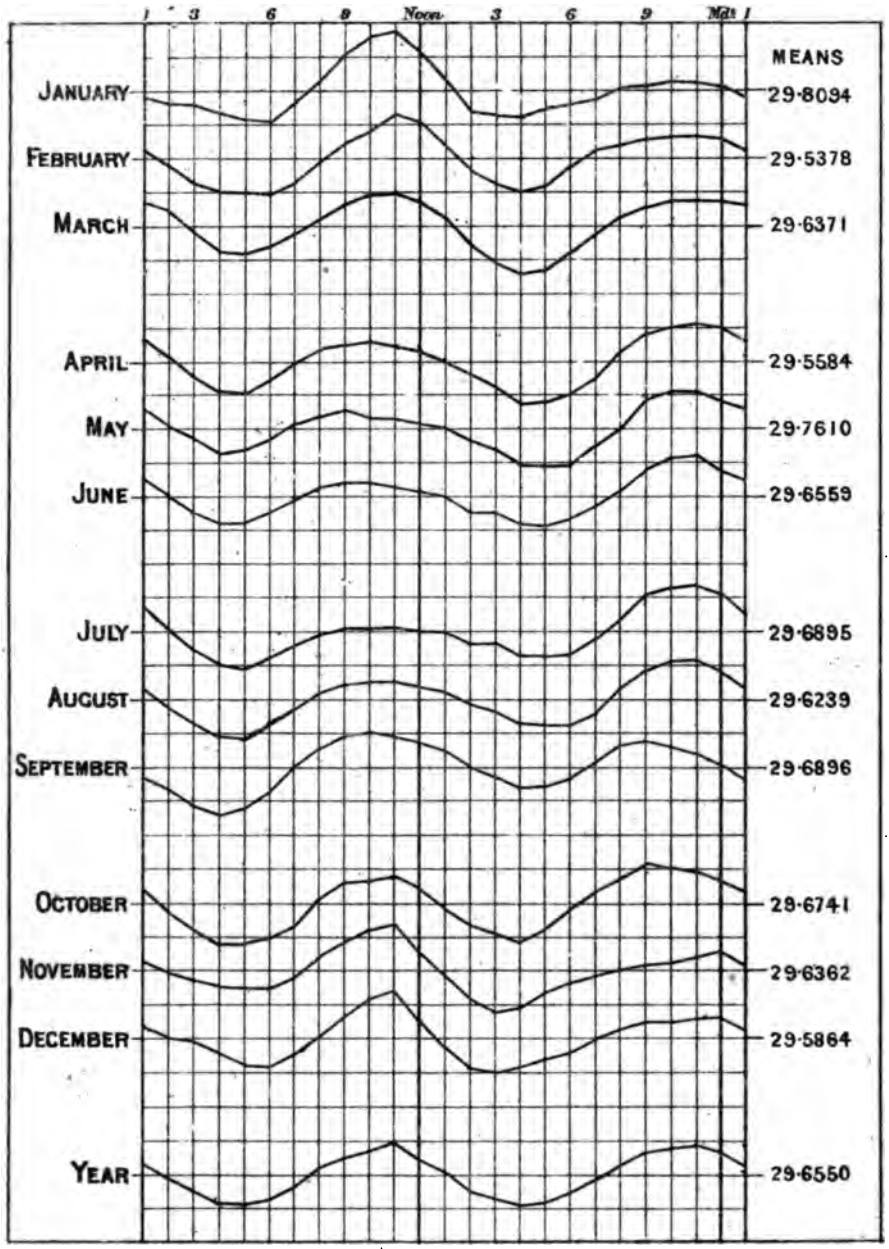


Barometer Scale, each division = 0·01 inch

...CERFIELD LITH 22, BEDFORD ST COVENT GARDEN 1796

MEAN DIURNAL VARIATION OF THE BAROMETER AT ARMAGH. 1876-1880.

Greenwich Time.

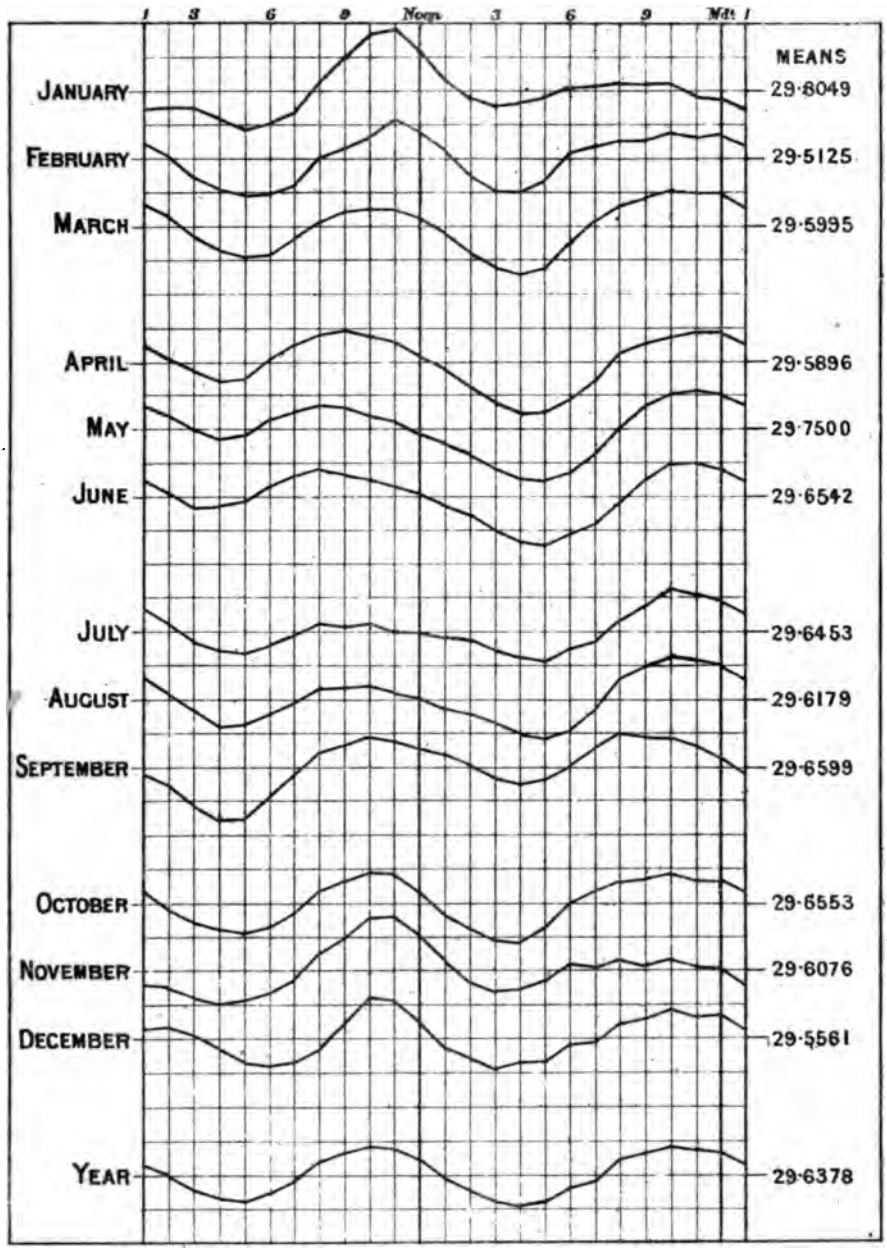


Barometer Scale, each division = 0·01 inch.

DANCERFIELD LITH. 22, BEDFORD ST COVENT GARDEN

MEAN DIURNAL VARIATION OF THE BAROMETER AT GLASGOW 1876-1880.

Greenwich Time.



Barometer Scale, each division = 0·01 inch.

DANCERFIELD LITH 22. BEDFORD ST COVENT GARDEN 1881

MEAN DIURNAL VARIATION OF THE BAROMETER AT ABERDEEN 1876-1880.

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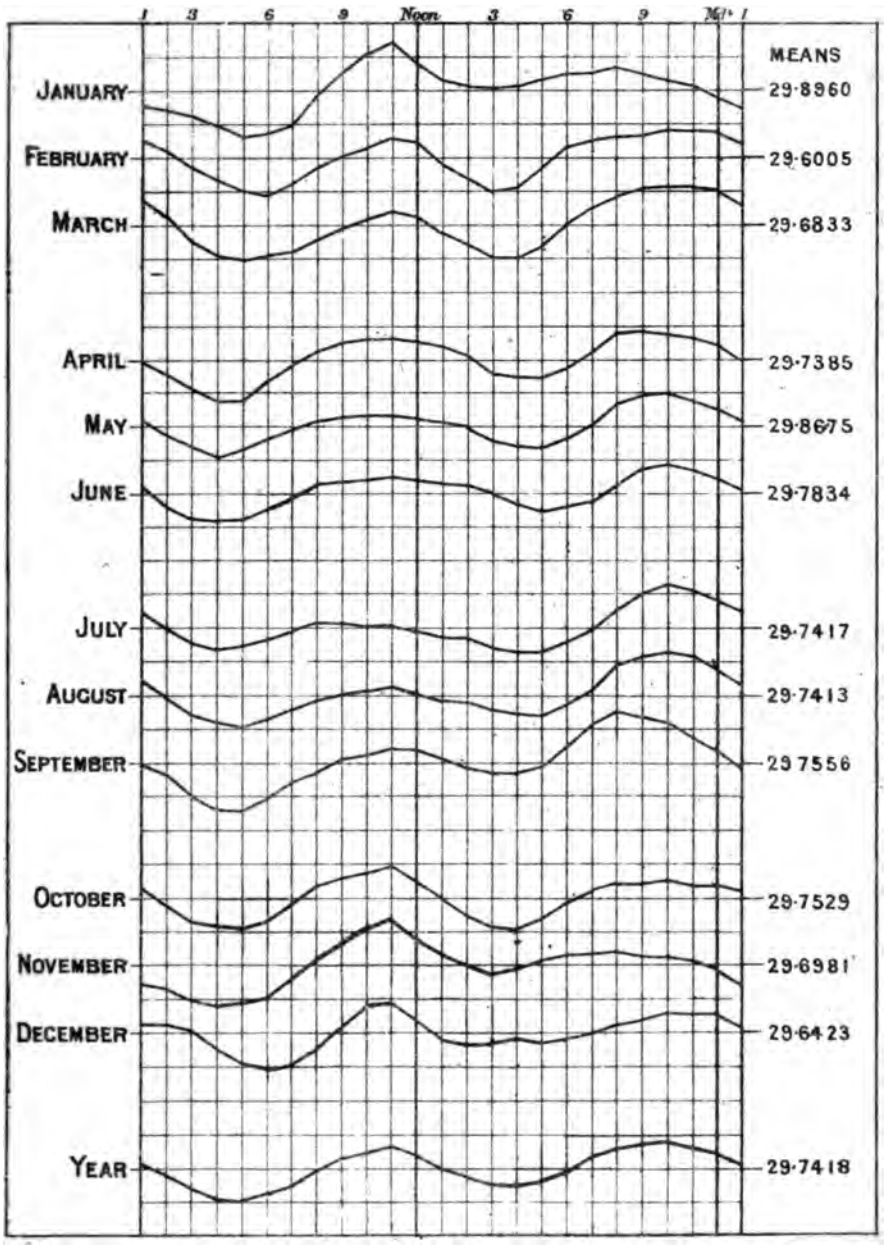

Barometer Scale, each division = 0·01 inch

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MEAN DIURNAL VARIATION OF THE BAROMETER AT FALMOUTH. 1876-1880.

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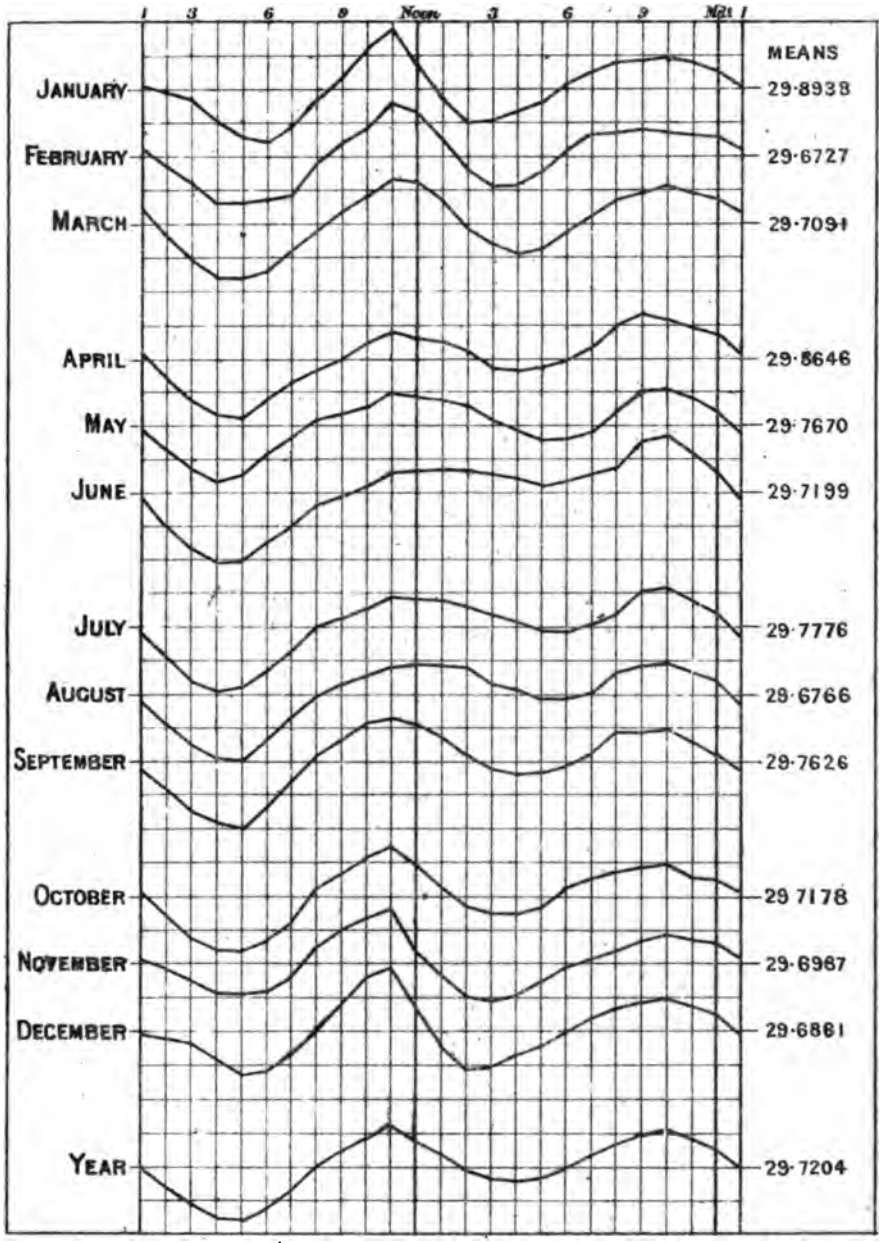

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MEAN DIURNAL VARIATION OF THE BAROMETER AT STONYHURST 1876-1880.

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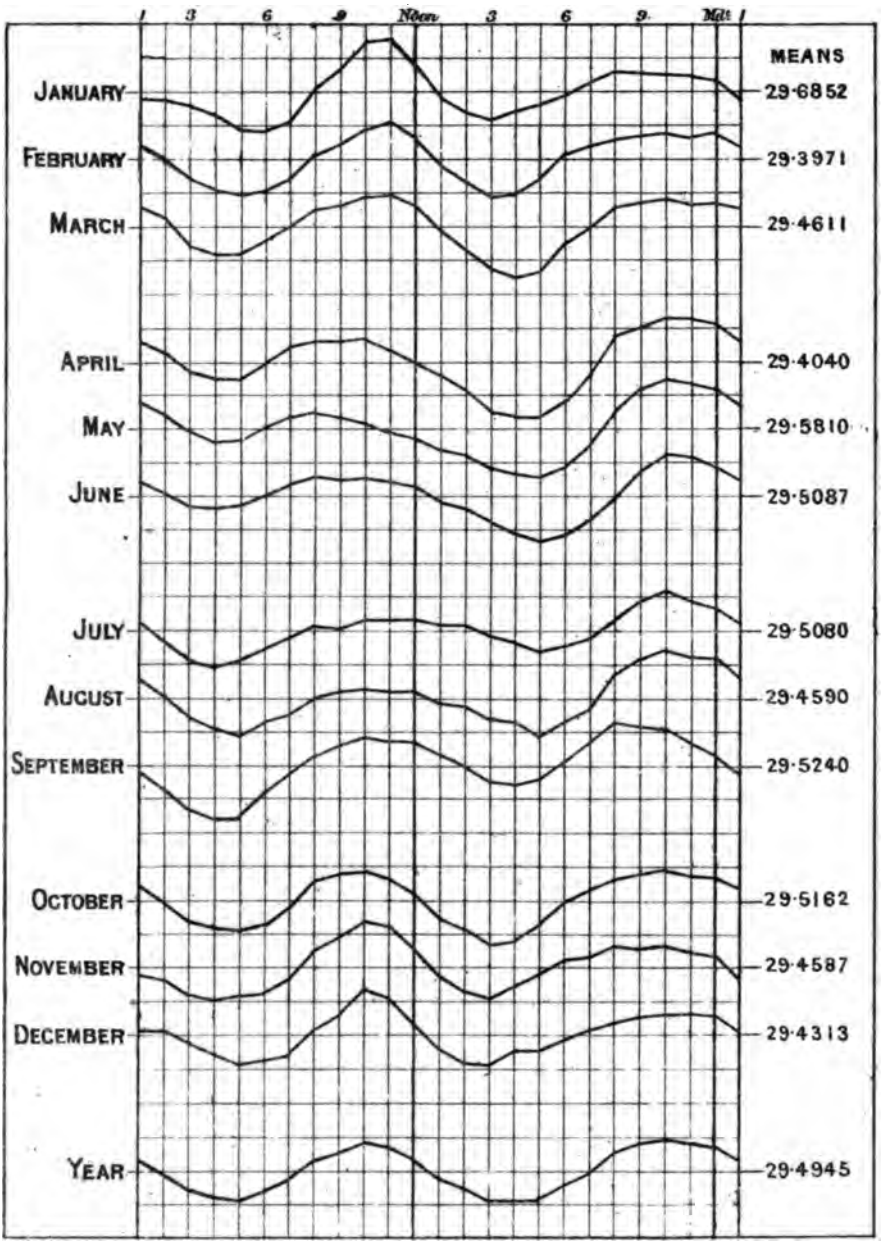

Barometer Scale, each division = 0·01 inch

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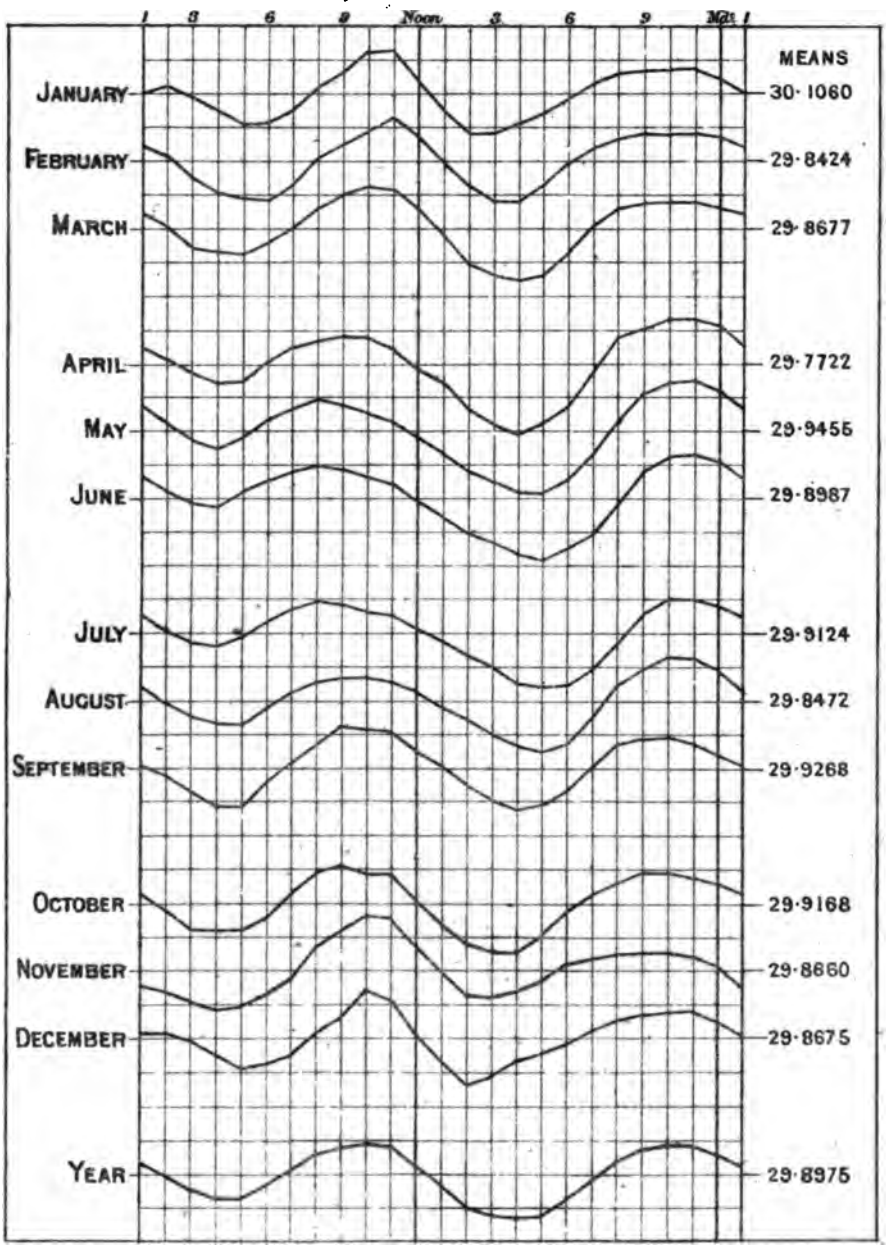
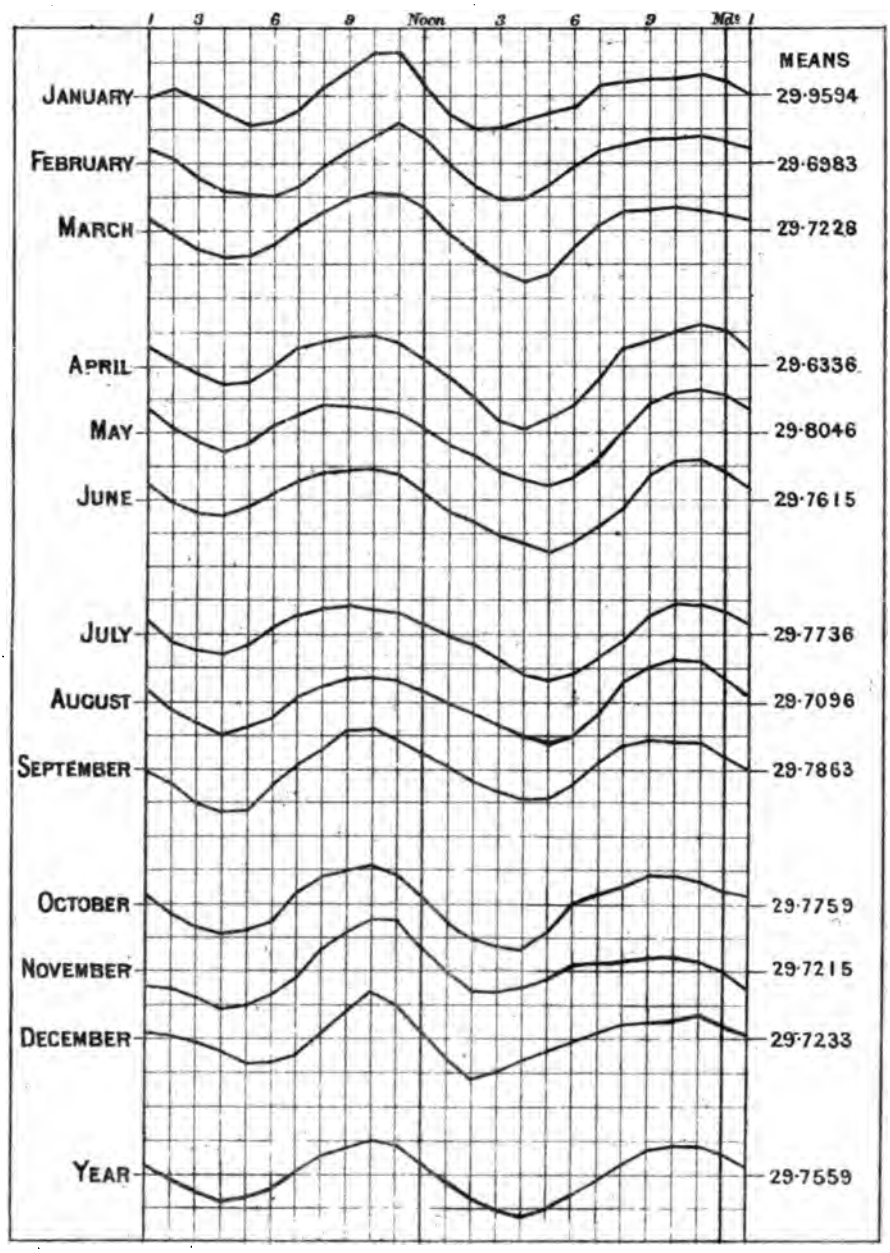


Barometer Scale, each division = 0·01 inch.

DANIELL FIELD LITH 22 BEDFORD ST COVENT GARDEN

MEAN DIURNAL VARIATION OF THE BAROMETER AT GREENWICH 1876-1880.

Greenwich Time.



Barometer Scale, each division = 0·01 inch

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MEAN DIURNAL VARIATION OF THE BAROMETER AT BIDSTON 1876-1880.

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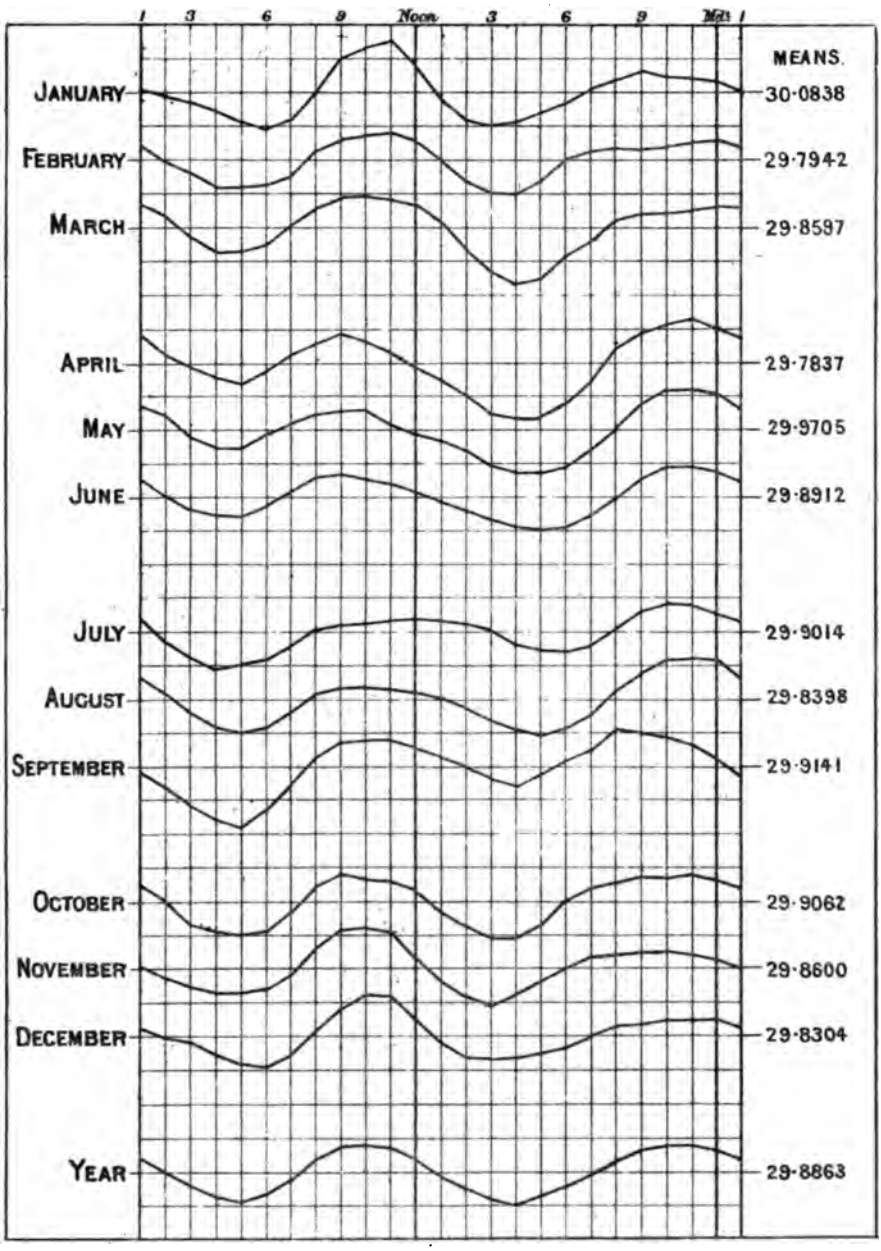

Barometer Scale, each division = 0·01 inch.

DAVENPORT LITH. 22, BEDFORD ST COVENT GARDEN &c.

Quarterly Journal

OF THE

ROYAL METEOROLOGICAL SOCIETY.

EDITED BY A

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Royal Meteorological Society.

Established 1850. Incorporated by Royal Charter, 1866.

Office:—30 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1889-90.

ORDINARY MEETINGS at 7 p.m.

Wednesday,	November	20,	1889.
,,	December	18,	,,
,,	January	15,	1890.
,,	February	19,	,,
,,	March	19,	,,
,,	April	16,	,,
,,	May	21,	,,
,,	June	18,	,,

ANNUAL GENERAL MEETING.

Wednesday, January ..... 15, 1890.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

NOTICE.

The Library and Offices of the Society are open daily from 10 a.m. to 5 p.m.; Saturdays, 10 a.m. to 2 p.m.

The Society is not responsible for the views and opinions advanced in the *Quarterly Journal*.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XV. OCTOBER 1889. No. 72.

ACCOUNT OF

Some Experiments made to Investigate the Connection between the Pressure and Velocity of the Wind.

BY W. H. DINES, B.A., F.R.MET.SOC.

[Read May 15th, 1889.]

THESE experiments have been made for the purpose of determining the relation between the velocity of the wind and the pressure it exerts upon obstacles of various kinds exposed to it.

It has long been known that wind pressure depends approximately upon the square of the velocity. If a weight be swung round in a curve, the restraint required to keep it in the curve varies, other things remaining the same, as the square of the velocity, and hence the idea occurred to me that this principle might be employed with advantage in these experiments. The plan has been found to answer admirably, and has obviated the necessity of determining the velocities of the bodies upon which experiments have been made, thus entirely avoiding one great source of error.

The pressure plates have been placed at the end of the long arm of the whirling machine previously described (*Quarterly Journal*, Vol. XIV. p. 253), and rotated by steam power.

The instrument for carrying the plates screws on to the end of the long arm A B, and consists essentially of a lever bent at right angles and pivoted at B (Fig. 1). The arm B C carrying the plate forms a continuation of the long arm of the whirler; the other arm E D is a graduated brass bar of known weight, which slides at right angles to B C, and can be clamped in any position. As the machine revolves about A, the sliding bar, unless its centre of mass, G, be on the pivot, tends to fly outwards in the direction G F, that is away from A, and thus to press the plate forwards, and the amount of this tendency, F, can be altered by shifting the position of the bar and thus altering the leverage.

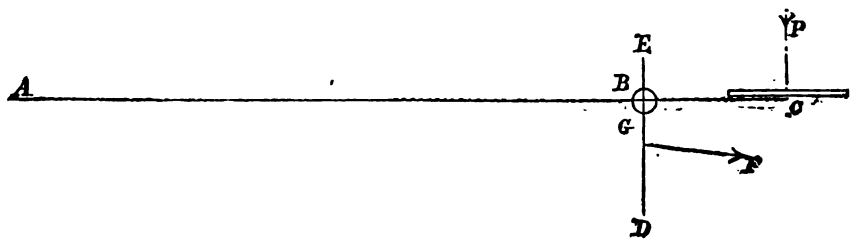

FIG. 1.

Hence the force urging the plate forwards depends upon three things, (1) the so-called centrifugal force, which itself depends, inversely upon the length of the long arm, and directly upon the square of the velocity; (2) upon the weight of the bar; and (3) on the distance of the centre of mass from the pivot. Of these (1) and (3) can be altered, (1) by altering the rate of rotation, and (3) by altering the position in which the bar is clamped. The force P, urging the plate backwards, depends upon the shape of the plate and upon the square of the velocity with which it is driven through the air. Of these the second can be altered, but any change in it produces an equal change in the force F, driving the plate forwards, and therefore does not alter the relative equilibrium. Hence, as stated above, the velocity does not come into question at all and need not be measured. When the position of equilibrium has been obtained, the wind pressure for any velocity is given by a simple mathematical calculation.[1]

[1] If C be the centre of pressure of the plate, w the weight of the sliding bar, v the velocity of the point B, V that of C, and r the length of the long arm $A\,B$, we have—

The component of F parallel to $A\,B = \frac{wv^2}{gr}$, and hence, taking moments about B,

$$P \cdot BC = \frac{wv^2}{gr} \cdot BG$$

But P varies as V^2, $P = kV^2$, suppose, when k is a constant, and also $V = \frac{AC}{AB}v$.

$$\therefore k\frac{AC^2}{AB^2}BC = \frac{w \cdot BG}{gr}$$

and substituting for the known quantities the value of k is found.

Strictly, the geometrical centre is not the centre of pressure of the plate, since the

It has been assumed in the above that the wind pressure varies as the square of the velocity. The experiments have proved this to be the case, for when upon a calm day equilibrium for any plate is once attained, it has been found impossible to disturb it by any alteration of the velocity of rotation, and since the centrifugal force varies as the square of the velocity, the wind pressure must do so also. For the smaller plates the maximum velocity of which the machine is capable is about 70 miles per hour.

In actual practice, some of the larger plates have been mounted upon a lever attached to a bevilled wheel, which geared into another equal wheel carrying the sliding bar. In some respects this arrangement was more convenient than the simple bent lever, being, however, identical with it in principle.

At first a difficulty was found in observing the position of the plate while it was moving, but this was overcome by the aid of electricity. A play of about 1° was allowed to the moving parts, the motion being checked by two stops. The stops were formed by insulated pieces of metal from which wires were led to a galvanometer and system of batteries. The system was so arranged that contact with one stop caused a current to flow through the galvanometer in one direction and contact with the other in the opposite direction. Thus it indicated the stop with which the lever was in contact at any instant, and therefore whether the wind pressure, or the centrifugal action upon the sliding bar, were the greater.

Three bars were used, graduated in decimals of a foot, and weighing 0·4, 1·0 and 2·0 lbs. respectively. The accuracy of the weights may be relied upon, Mr. Whipple having been kind enough to determine them for me at Kew. The measurements of length are more uncertain, but the error is certainly within 1 per cent.

The plan adopted was to place a plate and bar of suitable weight on the machine, and to keep stopping the motion and altering the position of the bar until either no current flowed through the galvanometer, or, as more often happened, until currents flowed in opposite directions at equal intervals. Sometimes two or three trials gave the right position, but occasionally the machine had to be stopped and started 15 or 20 times before a satisfactory result could be obtained. Hence I was led to introduce a small supplementary bar weighing ¼ lb., and an automatic arrangement, worked by a small windmill, into the details of which it is unnecessary to enter. Subsequent experience has made me think that the trouble arose from small variations in the actual pressure, occurring at short intervals, as results obtained within a few minutes sometimes differ by 2 or 3 per cent. That

velocity is greater upon the outer than upon the inner edge of the plate, but the difference of position for any plate used, when compared with AB, is inappreciable. The difference might be of consequence when compared with BC, but with the larger plates a pair of bevilled wheels have been introduced at B, so that the lever carrying the plate has moved in a vertical instead of in a horizontal plane, thus the centre of pressure and the geometrical centre were at the same distance from the axis of rotation of the lever, although at slightly different distances from the axis of the whirler.

the variations are not due to accidental errors is proved by the fact that they have only occurred with a Southerly or Westerly wind, and never during a North-Easterly wind. The whirling machine being somewhat sheltered on the South and South-west, it is probable that the effect of these winds is to induce slight eddies.

The question naturally arises how far the values given in the accompanying Table may be depended upon. The values are the mean of all the experiments made with each particular plate, the number of experiments made with each being given in the last column of the table. Each experiment consisted of about three observations taken in immediate succession. As a rule no plate was tried twice on the same day. With the larger plates a single value has seldom differed from the mean by more than 5 per cent., and on the whole the different values have been fairly consistent. There are, however, two cases of exception to this statement, and they are the cylindrical surface and the sharp cone when placed in front of the plate. The results of five experiments out of the series of about 150 have been rejected.

The particular value of 20·86 miles per hour for the velocity given in the Table is chosen for the following reason:—The centre of the pivot was 28 ft. 1 in. from the axis of rotation of the whirling machine, and the centre of the plate 28 ft. 7 in.

Taking the numerical value of the acceleration due to gravity (g) as 32·19, these figures give 20·86 miles per hour as the velocity of the centre of the plates at which the centrifugal force acting upon the bar is equal to its weight.

Experiments have also been made with two kinds of perforated zinc. The pressure on the first kind, which contains about 77 holes of ·08 in. diameter per square inch, was 9 per cent. less than on a solid plate, but gave the high value of 2·48 lbs. pressure per square foot of actual surface. The values for the second kind, having 11 to 12 holes of ·22 in. diameter per square inch, were 20 per cent less than on a solid plate, and gave about 2 lbs. per square foot of actual surface.

It was necessary to stiffen these plates by turning up the edges, and it was found that this edge when presented to the wind increased the pressure by about 6 per cent.

A cone and a projecting rim, when put at the back of the foot circular plate, caused no appreciable alteration in the pressure, but when the rim projected in front the results were—

An increase of	6	per cent. with a projection of	$\frac{1}{8}$	in.
,,	,, 10	,,	,,	$\frac{3}{8}$,,
,,	,, 14	,,	,,	$\frac{5}{8}$,,

The effect of cutting holes in the foot square plate was also tried—8 circular holes, each of one square inch area, being made, 4 as near the centre as possible, and 1 close to each corner. No difference in the pressure could be detected, whether any or all of the holes were covered or open. The 8 holes together

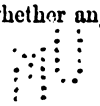

TABLE SHOWING THE PRESSURE UPON VARIOUS PLATES AT A VELOCITY OF 20·86 MILES PER HOUR. THE VALUES ARE REDUCED TO THE STANDARD TEMPERATURE AND PRESSURE. THE FLAT PLATES WERE CUT OUT OF HARD WOOD $\frac{3}{8}$ IN. THICK. ALLOWANCE HAS BEEN MADE FOR THE ARM WHICH CARRIED THEM.

Plates.	Actual Pressure in lbs.	Pressure in lbs. per square foot.	No. of Experiments.
A square, each side 4 ins.	·17	1·51	4
A circle, 4·51 ins. diameter, same area	·17	1·51	9
A rectangle, 16 × 1 ins.	·19	1·70	7
A circle, 6 ins. diameter	·29	1·47	7
A square, each side 8 ins.	·66	1·48	8
A circle, 9·03 ins. diameter, same area	·67	1·50	12
A rectangle, 16 × 4 ins.	·70	1·58	4
A square, each side 12 ins.	1·57	1·57	7
A circle, 13·54 ins. diameter, same area	1·55	1·55	14
A rectangle, 24 × 6 ins.	1·56	1·59	6
A square, each side 16 ins.	2·70	1·52	6
A plate, 6 ins. diameter, $4\frac{3}{4}$ ins. thick	·28	1·45	5
A cylinder, 6 ins. diameter and $4\frac{1}{4}$ ins. long	·18	0·92	4
A sphere, 6 ins. diameter	·13	0·67	8
A plate, 6 ins. diameter, with a blunt cone, angle 90°, at the back	·29	1·49	4
The same, with cone in front	·19	0·98	4
A plate, 6 ins. diameter, with a sharp cone, angle 30°, at the back	·30	1·54	4
The same, with cone in front	·12	0·60	4
A 5 inch Robinson cup, mounted on $8\frac{1}{2}$ ins. of $\frac{1}{8}$ in. rod	·28	1·68	8
The same, with its back to the wind	·12	0·73	4
A 9 inch cup, mounted on $6\frac{1}{2}$ ins. of $\frac{3}{8}$ in. rod	·82	1·75	3
The same, with its back to the wind	·28	0·60	3
A $2\frac{1}{2}$ inch cup, mounted on $9\frac{3}{4}$ ins. of $\frac{1}{4}$ in. rod	·13	2·60	3
The same, with its back to the wind	·05	1·04	3
One foot of $\frac{1}{8}$ in. circular rod	·09	1·71	9

take away more than 5 per cent. of the plate, yet a difference of 1 per cent. in the pressure, had it existed, would certainly have been apparent.

The results of the table may be roughly summarised as follows :—The pressure upon a plane area of fairly compact form is about $1\frac{1}{2}$ lb. per square foot at a velocity of 21 miles per hour, or in other words, a pressure of 1 lb. per square foot is caused by a wind of a little more than 17 miles per hour.

The pressure upon the same area is increased by increasing the perimeter. The pressure upon a $\frac{1}{4}$ ft. plate is proportionally less than that upon a plate either half or double its size. The pressure upon any surface is but slightly altered by a cone or rim projecting at the back, a cone seeming to cause a slight increase, but a rim having apparently no effect. This result is of importance, since a pressure plate for permanent use should be of some material which will not warp, and if thin metal be used a rim is necessary to obtain the requisite stiffness. As might be expected, a cone in front greatly reduces the pressure.

There are many directions in which it would be interesting to push this investigation ; so many, indeed, that it is difficult to choose between them. I hope, however, to be able to extend the results to larger surfaces by some

method of comparison, such as balancing two plates exposed to the natural wind against each other by levers of different lengths; also to check this series of experiments and those made by Mr. Whipple and myself with the Robinson cups last year by placing a set of hemispherical cups with a maximum speed indicator attached by the side of a maximum pressure plate.

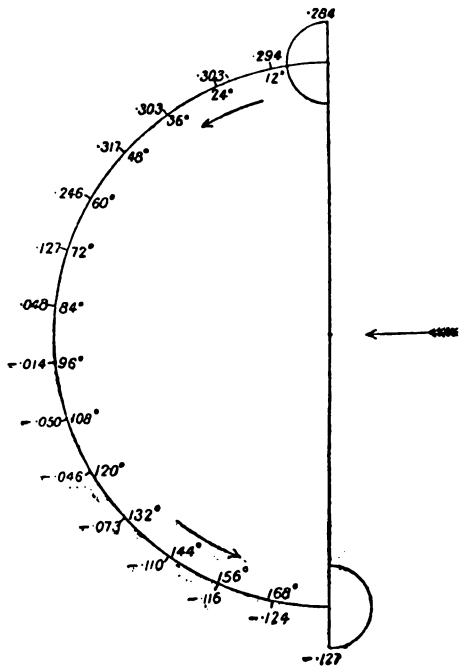

FIG. 2.

Fig. 2 shows the moment in feet and pounds of the force exerted by the wind when blowing at a rate of 20·94 miles per hour upon a 5 inch Robinson cup, mounted on ½ in. rod with its centre 1 foot from the axis. The figures placed against the angles indicate the moment exerted when the cup is in the corresponding position. The moment is of course negative in the lower half of the circle.

The values in the other half of the circle are practically symmetrical.

In conclusion, I have to acknowledge the assistance of Mr. Whipple in some of the experiments, and his kindness in measuring some of the plates, also to thank various Fellows of the Society for their suggestions, and the Meteorological Council, for a grant which has enabled me to carry on the experiments.

DISCUSSION.

THE PRESIDENT (Dr. Marcet) took advantage of the opportunity to thank Mr. Dines for his kindness and courtesy in inviting the Council and Fellows of the Society to witness his experiments at Hersham. The visit had proved highly

interesting. He congratulated Mr. Dines on the success of his experiments, observing that it was remarkable the circular holes in the pressure plates failed to cause any difference in the amount of wind pressure.

Dr. TRIPE congratulated Mr. Dines on having attained such good results, with what at first sight appeared to be such primitive apparatus. He could not but admire the great amount of mechanical knowledge displayed in the construction of the whirling machine, and in the various contrivances devised by Mr. Dines for satisfactorily carrying out these experiments. The uniformity of the wind pressure upon the different sizes and shapes of flat plates of the different sizes experimented with, was a very striking result. He was surprised, too, that the pressure upon a small area should be so high compared with the pressure upon larger plates. One of the chief points of these experiments was that reliable pressure results had been obtained for a given wind velocity, but it must not be supposed that twice this given velocity would give only twice the ascertained pressure at double the velocity, because the pressure varied nearly as the square of the velocity.

Mr. BALDWIN LATHAM said that the results obtained by Mr. Dines would be extremely valuable to the engineering profession. It was curious that they came very near to the ordinary rules adopted by engineers in the construction of works in which wind pressure had to be taken into account. It was generally assumed that the pressure of the wind upon a circular chimney was about 30 per cent. less than on a square one, and Mr. Dines' experiments showed this was correct. He hoped Mr. Dines would continue these experiments and ascertain the pressure upon other structural forms, such as the prism, in order to ascertain the effect of an angle presented to the wind, and also upon octagonal columns, which form was much used in the construction of chimney shafts.

Mr. CHATTERTON felt sure that there were very few engineers who would not be gratified with the results embodied in Mr. Dines's paper. The experiments were certainly the most complete that he knew of. With regard to the pressure plate perforated with holes, if we could imagine that to represent a section of a lattice girder bridge, it appeared that the rule among engineers in calculating the amount of pressure such a bridge would have to withstand was wrong, for the calculation was usually based upon the area of the iron surface only. He would like Mr. Dines to make similar experiments to those described in the present paper at higher velocities, say up to 60 or 70 miles per hour.

Mr. LAUGHTON said that he did not understand the varying pressure on varying areas. Were we also to assume, from the experiments made with a perforated plate, that the pressure upon a lattice surface, such as, for instance, the Eiffel Tower in Paris, was the same as upon a close surface? He should like to see some more pressure experiments made in this direction. The effect of a varying perimeter, the area of the surface remaining the same, also needed further investigation. Meteorologists and engineers certainly owed Mr. Dines their hearty thanks for the work he had accomplished.

Mr. WHIPPLE said the Society was fortunate in having in Mr. Dines a gentleman who not only possessed the ability as a mathematician and a mechanical engineer to carry out these experiments, but also had the leisure to devote to such work. The results of these pressure experiments were of extremely great interest, and certainly showed that meteorologists had been working in the dark in the question of anemometry. The effect of a cone at the back of the plate was an important matter, it being generally supposed to make some difference in the amount of pressure upon the front of the plate. The late Mr. Cator had considered the introduction of this cone an important feature in his recording anemometer, but Mr. Dines's experiments showed that a cone made no appreciable difference in the pressure exerted upon the plate. It was curious that a rectangular plate 16 ins. by 1 in. should experience a pressure of 1·70 lbs. while the pressure upon a square plate of the same area was 1·51 lbs. The results obtained from experiments with perforated zinc plates were certainly most interesting. It was also remarkable that the pressure upon a Robinson cup should be greater when inclined at an angle to the direction of the wind than when the wind was blowing directly upon it. He thought these experiments would put us in the way of getting accurate results on this question. Regarding the methods adopted by Mr. Dines, he could not but admire the ingenuity displayed in fixing the pressure plates to the arm of the whirling machine.

Mr. C. HARDING inquired whether Mr. Dines had tested the perforated plate at different velocities, as one would suppose the effect would be different at different velocities. The usual formula for ascertaining pressure from velocity was vel. sq. $\times \cdot 005 = P$, and this would give, for a velocity of 21 miles per hour, a pressure of 2·2 lbs. on the square foot, instead of 1·5 lbs. as shown by the experiments. An important feature of Mr. Dines's machine was that it created no swirl of air.

Mr. ELLIS said that it was very satisfactory to find that the pressure in lbs. on the square foot came out so nearly the same with the various sizes and shapes of simple plates used, for this fact was important as affecting anemometers, the size of the pressure plate of the Osler anemometer of the Royal Observatory having, for instance, been more than once changed. It had been a question whether plates of different sizes gave accordant results, and it now seems that within small limits they do so. It was to be hoped that Mr. Dines would be able to further continue these important experiments, in which evidently there was so much that might be done. The results refer to mean pressure. Of course, greater pressures are registered than these experiments, on the ordinary relation of velocity to pressure, indicate as probable, although extreme pressures were perhaps not really so great as had once been supposed.

Mr. LECKY thought a good deal depended on the size of the holes, and suggested the trial of what the effect would be if the same area were removed from the plate by one or two holes instead of by eight.

Mr. HARRIES remarked that Mr. Dines had shown by previous experiments that the factor for Robinson's cups should be reduced by about 29 per cent., and now the result of his experiments for the present paper showed nearly the same reduction necessary in the factor hitherto used for converting velocity into pressure. The significance of these modifications would be better understood if we take an anemometrical record which, under the old rule, would be represented by a velocity of 70 miles an hour, or a pressure of 24·5 lbs. per square foot. By the most recent factors the velocity falls to 50 miles, and the pressure to 9 lbs.

Mr. W. H. DINES, in reply, said that he had made experiments at every velocity of which the machine was capable, and that the pressure at any velocity could be obtained from that given in the table by remembering that the pressures varied as the squares of the velocity. He could not give any reason for the fact, but certainly the pressure upon a small area, such as a circle of 2 or 3 inches diameter, or a strip 1 or 2 inches wide, was proportionally greater than upon a larger area. He thought that this explained the curious result obtained when holes were drilled in the flat square plate. Parts of it then approximated in form to a narrow strip, and the increase of pressure upon these parts compensated for the loss of total area. The experiments showed that increasing the perimeter increased the pressure, and thus the wind pressure upon a lattice girder would be greater than upon the same total area collected into a compact form. Placing a cone at the back seemed, if anything, to increase the pressure, and this did not uphold the theory that a partial vacuum was formed at the back. This result was not surprising, since theory showed that in cases of steady motion the velocity was greatest where the pressure was least, and as the motion of the air at the back of a plate could not be very rapid, we could not expect any decrease of pressure. The old formula was $P = \cdot 005\ v^2$; P being the pressure in lbs. per sq. ft., and v the velocity in miles per hour, but some recent books had substituted ·003 for ·005, and this new value agreed with his experiments. He thought it useless to try to compare the pressure with the record of a velocity anemometer, because, apart from the uncertainty about the value of the Robinson factor, it was only the mean velocity over a considerable period that was recorded. He had just seen the account of some recent American experiments which showed that the anemometer used by the Signal Service generally gave 10 per cent. too high a velocity, in consequence of the tendency of the instrument to record the mean square rather than the mean velocity of a variable wind.

Mr. WHIPPLE remarked that the factor for converting pressure into velocity was originally given as ·0023. Regarding the American experiments referred to by Mr. Dines, it was noteworthy that the apparatus used was almost an exact copy of that constructed by Mr. Dines.

WIND STORM AT SYDNEY, NEW SOUTH WALES, JANUARY 27th, 1889.

By H. C. RUSSELL, B.A., F.R.S., Government Astronomer.

[Received May 1st—Read May 15th, 1889.]

The following case of house destruction by wind may be of interest to the Fellows of the Royal Meteorological Society:—

On Sunday, January 27th, 1889, I was standing in the Observatory garden, watching a thunderstorm approach from West-south-west against a fresh North-east wind. The storm-cloud seemed very dense, and lightning came from it frequently. At 3.50 p.m., seeing that the squall was just upon us, I went into the Observatory and made the electrical contacts for recording gusts of wind: this recorded the most severe gust, at 3h. 53m., as having a velocity of 68 miles an hour, and for two minutes the record showed many gusts equal to 60 miles per hour. About 3 miles west of the Observatory a house was completely shattered.

The owner's story is as follows:—"I was standing in my bedroom, playing with my child, and my wife was sitting near me. Hearing a great noise, I looked up and saw the roof disappearing, and the three stone walls falling away from me, while at the same moment the wooden partition fell against my back. Neither my wife, child, nor myself were hurt in any way, but our iron tubular bedstead was destroyed, three of the legs being broken off just under the mattress; the rest of the furniture was more or less damaged, and the wonder to me is that we were not killed. It all happened in a moment, and I cannot give you any more particulars; it seemed all so quick, I had no time to see what was going on."

It is clear that the walls fell east and west, each in one piece, and that the joints did not break until they struck the ground. The shop front was carried bodily some distance down the street eastward, and the roof disappeared entirely; the next house eastward was not damaged; the one west of it had part of the roof carried away. About 200 yards east stands a badly built two-storied house. All the covering of the roof was taken off this, and the walls cracked so much that they are no longer safe. About 150 yards further on stood a tree (the common willow), the stem of which was broken off at eight feet from the ground, where it was 18 inches in diameter. This tree stood in the yard of a cottage which next felt the force of the wind; the roof was pushed out of shape, *but not lifted*, and the verandah roof in front was torn off (the cottage faced east). The gust then seems to have crossed an arm of the harbour and damaged some houses there, but not to any serious extent.

The area of damage is small, only about 350 yards long and 60 yards

wide; there are not many houses at this point, but enough to indicate the limits, and they are all poorly built.

The velocity of the wind must have been very much greater where the house was blown down than at the Observatory; and it should be mentioned here that a careful examination of all the buildings injured for traces of electrical action revealed nothing. The line of damage, which I assume to be the direction of the gust of wind that did it, is from North-west to South-east, and the storm was moving from West-south-west to East-north-east.

The house destroyed stood between two others; the one to the west of it being a little larger, but having its walls made up of fragments of stone, not solid rectangular blocks like the other, and it received very little damage. There is a slight depression in the ground, and the wind came down this on to the house that was destroyed.

The damage may have arisen in this way: the wind rushing down the street in front of the houses drew out the shop front, which in falling acted as a shoot, or windsail, and turned the wind into the house, where it lifted the roof and forced out all the walls; but this view does not account for the man's experience, viz. that the partition fell against him without hurting him, for he was standing between the partition and the back wall, and if the wind had come in the front way with force enough to drive out all the walls, he must have been injured between the partition and the back wall, for the partition extended right across from wall to wall, and was fastened to the fillet. Nor does it account for the damage done to the bedstead.

The other view, viz. that the wind going over the house created such a vacuum that the air within, expanding, forced out the walls and lifted the roof, would accord with the man's statement, "that the partition *fell* against him without injuring him;" but it also fails to account for the broken bedstead, and it is difficult to see why in that case the adjoining houses did not have their roofs lifted also. The man when questioned said that he heard thunder "8 or 4 minutes" before the house fell, but none at the time, agreeing with my own observation; for I saw no lightning nearer to the Observatory than 4 miles, judging by the interval from flash to sound, and that was not in the direction of the house destroyed, but to the south of it, as seen from the Observatory.

There was nothing worthy of special note in the barometer changes: there was but a slight change, and the slight depression in the ground down which the gust came seems to me insufficient to account for the intensity at the point of damage, and there is certainly no obvious reason why the houses on the left should have escaped; they are not so strongly built, and have nothing to protect them on the side the wind came from, while they stood as a protection to the house destroyed. The only difference of any importance was that they were dwelling-houses with small windows and doors, and an otherwise solid front, while the house destroyed had a light front of wood and glass.

DISCUSSION.

Mr. WHIPPLE said that this storm appeared to be analogous to some of the American cyclone storms. He had read accounts of this kind of tornadoes in the reports of the United States Signal Service. It was interesting to have photographs of the damage done by such storms, as they tended to confirm the accounts describing the violence of the wind. He recollected that Mr. Symons, some years ago, read an account of a similar storm which occurred at Walmer, in Kent.

ON AN IMPROVED METHOD OF PREPARING OZONE PAPER,

And other Forms of the Test, with Starch and Potassium Iodide.

By CHARLES HARRISON BLACKLEY, M.D., F.R.Met.Soc.

(Plate XI.)

[Received March 21st.—Read May 15th, 1889.]

Some twenty-five years ago I had occasion to make a series of experiments on the action of ozone on the respiratory passages. At that time the two test papers in general use were Schönbein's and Moffatt's. My first experiments were made with papers prepared on Schönbein's method, which had been procured from one of the London dealers. For the object I had then in view these answered very well; but on making further experiments, for the purpose of getting some idea of the relative amounts of ozone in the atmosphere at various points on the scale, I found the slips of test paper did not always give the same result when two or more were exposed under precisely the same conditions. Occasionally, when three or four slips were exposed together, no two of them would be exactly alike;[1] and there would often be a difference of two degrees of Schönbein's scale between them.

This defect led me to endeavour to correct it by having the test papers prepared under my own superintendence with varying modes of manipulation, and also by combining other materials with the starch and the re-agent. So far as the paper process was concerned, the result, though better, was not a success. Other methods were also tried by having the starch and potassium iodide combined with gypsum, with oxide of zinc, or with chalk.

In the case of the two latter they were either spread upon paper or used in the form of dry powder. In the case of the gypsum, the starch and the re-agent were mixed with it and with water, and then cast into thin plates.

[1] From a correspondence I had at that time with the late Prof. Daubeny, of Oxford, it appeared that he and others had similar experience.

These various methods gave rather better results, but were not as even and trustworthy in their action as was desirable.

In the course of these experiments it occurred to me that it might be well to try what reaction would take place between unboiled starch and potassium iodide when exposed to the influence of ozone; but the difficulty of getting this spread evenly upon paper by hand, so as to ensure a perfectly even tint, after being acted upon by ozone, led me to devise a somewhat novel method of accomplishing this. Briefly described, it may be said to be a method by which the starch is deposited on the surface of the paper by precipitation, and for delicacy and precision in regulating the quantity on any given surface it leaves, I think, very little to be desired.

For many years these investigations have remained in abeyance, owing to lack of time to enable some of the details of the method to be completed. Having, however, lately taken the subject up again, I have thought it desirable to bring my method of working under the notice of the Society. In describing the plan pursued, this may for convenience be divided into two parts. The first object was, as I have intimated above, to deposit upon a given surface a given quantity of the unboiled starch; and secondly, to charge this with a given quantity of the potassium iodide, so that any portion of a sheet should contain exactly the same quantity of the starch and the re-agent as any other portion of the same area.

The apparatus shown in figs. 1, 2 and 3 (Plate XI.) makes, when fitted up, a sort of shallow cistern, which allows the starch to settle down, whilst at the same time it permits the water to drain away.

The sheet of plate glass H (shown in fig. 3) is covered with stout cambric drawn tightly over it and fastened at the back. This is then well wetted with distilled water, and upon this is placed a quarter of a sheet of the best English filtering paper (demy), after having been soaked in distilled water. These are then placed upon the frame A, and levelled carefully by the aid of a spirit level, and by means of the feet D D D. The frame E F is then placed exactly in the centre of the sheet, and the weights J J J J are placed in position, as shown in fig. 3. The spirit level should now be used again, to ascertain if the glass plate is still perfectly horizontal. The sheet is now ready for receiving its charge of starch; but it is necessary here to say that, if this is deposited pure on the surface of the paper, it will lie on it as a partially loose powder unless it is fixed in some way. This is easily done by boiling two grains of starch in 3,000 grains of distilled water (= 1 in 1,500), and by adding to this the quantity of starch[1] to be deposited after the fluid is quite cold.

In the specimen on page 1 of the book exhibited a frame of 20 centimètres wide by 26 centimètres long has been used. This would give 520 square centimètres. If, however, I had to begin the experiments again, I should make the frame 20 by 25 centimètres, for reasons that will presently

[1] I have used various kinds of starch, but on the whole prefer Colman's No. 1 White Starch to any that I have tried so far.

be given. A frame of these latter dimensions would enclose a space that would contain 500 square centimètres. Twenty-five grains of starch (with a surplus of three grains for waste) are now gently moistened, and the 3,000 grains of starch water, spoken of above, are added to the starch. The mixture is then filtered by being run through a couple of layers of coarsish muslin, and, after being well stirred so as to keep the starch equally diffused through the water, the entire quantity is poured quickly into the space surrounded by the frame E F. This is then covered, and the whole is allowed to stand for three hours. At the end of this time the starch will have deposited, and the water will almost entirely have drained away, so as to allow the glass plate to be raised up so that the sheet may dry *in situ*. Each square centimètre will contain 0·05 of a grain of starch, or $\frac{1}{20}$th of a grain. If the various processes have been properly managed, the sheet will have the appearance of the specimen on page 1 of the book, and it will be seen, when examined by transmitted light, to have a perfectly even layer of starch in every part of the sheet that has been enclosed by the frame.

The next process is to charge the sheet with its due quantity of potassium iodide; and this is, perhaps, one of the most important, and, at the same time, one of the most delicate, of the processes, but is quite easy if care is taken.

In covering the paper with its layer of starch it is not a matter of much consequence what thickness of paper is used; but it becomes a matter of considerable importance when we come to charge the sheet with potassium iodide. The English filtering paper used in these later experiments weighed a little over 52 grains to the quarter sheet of demy (522 grains to the ten quarter sheets). These vary a little, but not so much as to affect the depth of colour very perceptibly after being prepared and exposed to the action of ozone. This paper is somewhat irregular in its texture, and this accounts for the dappled appearance of some of the specimens, but on account of its freedom from chemical substances likely to affect the action of the iodide, it is, on the whole, preferable to any that I have tried hitherto. It is, however, probable that a paper of a perfectly even texture and at the same time free from size or any chemical substance capable of interfering with the action of the ozone will yet be obtained.

In working now I cut down the quarter sheets at one end so as to weigh an average of 50 grains each. On trial it was found that a quarter sheet of this weight would easily take up 200 grains of water without allowing any of it to run off if placed upon a sheet of plate-glass that had been set perfectly horizontal. But to the weight of the sheet of 50 grains (if prepared with its charge of starch) 25 grains in weight must be added, so that the whole would weigh 75 grains. To saturate this with a ten per cent. solution[1] of the iodide we dissolve 7½ grains of the latter in 200 grains of water, and after this has

[1] In my experiments I have used both a ten per cent. and a five per cent. solution, and it is not yet quite a settled question with me which will be the better to be used, but it would take up too much space to discuss the matter in the present paper. A "ten per cent. solution" means simply ten per cent. of the weight of paper and starch.

been allowed to saturate the sheet in the manner indicated above it is allowed to stand in a warm room until the water has almost entirely evaporated. A frame, similar to the frame E F, but measuring one centimètre larger each way, is now placed upon the sheet, and after the edges have been pasted and turned up on to the frame the sheet may be lifted and placed horizontally, and when dried is ready for use.

In the specimens submitted it will at once be noticed that the colour is very different to that obtained by using Schönbein's or Moffatt's paper. In these papers, as every meteorologist knows, the colour is at first of a purplish tinge, changing to blue on being soaked in water. In the specimens submitted the tint, as will be seen, varies from a pale delicate yellow to a deep rich brown, or even to a brownish black. It will, however, only be after a very prolonged exposure to the influence of ozone that the papers will show the deeper shades of the colour. As a rule they will not pass much beyond the middle tints with a twelve or twenty-four hours' exposure.

The cause of this difference in colour between papers prepared with boiled starch and those prepared with unboiled starch, on my method, is not very easy to explain. Possibly it may be due to some alteration in the chemical condition of the starch which boiling produces, or it may be due to mere differences in the physical condition, causing some colours to be absorbed in the one case and reflected in the other. There is, however, this curious fact connected with the phenomenon, that if a piece of the paper, prepared with the unboiled starch, is submitted to the action of the vapour of iodine before it has been charged with the potassium iodide, it exhibits the purplish tinge and not the pale yellow or the brown. It is also important to notice another difference between the two papers. In those prepared with the boiled starch the colour begins to fade as soon as the paper has been made wet. In those prepared with the unboiled starch the colour is much less affected by being made wet; the paper may be wetted and dried several times before it is entirely driven off, unless the potassium iodide is entirely dissolved out of it at the first wetting. Another important difference is that in the last-named paper there is no actual change of colour when wetted, as there is in the other. The tint is deepened for the time being, but on drying it resumes its former shade or becomes a little paler.

For many years it has been a favourite idea with me that if the tint could be fixed by some means after the papers had by exposure been coloured up to any point in a given scale, it would be an advantage.

Many attempts were made to do this, but with very unsatisfactory results until recently. Latterly I have used a thin solution of gum mastic in benzine (such as is used by the photographers, and is called by them Crystal Varnish). When the papers are soaked in this varnish, after being coloured, it simply deepens the colour, just as in wetting, but it remains deepened, and so far as I can judge at present, appears to be more or less permanent.[1]

[1] After soaking, the superfluous varnish should be rapidly absorbed by blotting paper, so as not to allow the paper to leave any gloss upon it when dried.

The specimens on pages 2, 3 and 4 of the book[1] exhibit the difference between the unvarnished and the varnished. Nos. 2 and 3 are pieces that have undergone exactly the same exposure, having been cut from the same sheet. No. 3 is the varnished portion. No. 2 is the unvarnished one. Nos. 4 and 5 in like manner are portions from another sheet, and have had the same exposure, but No. 4 is the unvarnished one and No. 5 is the varnished one. Nos. 6, 7, 8 and 9 are specimens of deeper shades. Nos. 7 and 9 are varnished, 6 and 8 are unvarnished; and it will be noticed that these are undergoing some change on the margins of the papers, whilst the other two pieces are unchanged.

Nos. 10 and 11 are again still deeper shades, such as are rarely ever seen. Nos. 12 and 13 have been partly coloured by ozone at the sea-side, and partly by exposure to the vapour of iodine. In each pair of specimens the deeper tint is the varnished one, but the pair has in every case been subjected to the same influences.

On page 7 are other specimens showing also the difference that varnishing makes in the lighter tints. By a comparison of the difference made in the lighter and the deeper shades, it would appear that this difference increases in a somewhat geometrical ratio.

On page 8 (No. 23) is an entire quarter sheet that has been exposed and varnished to give an idea of the regularity of tint that may be got if due care is taken. The slips top and bottom are unvarnished, and show the tint of the larger sheet before being varnished.

On page 5 are four specimens (cut from the same sheet) which show the irregularity that sometimes occurs in the preparation of papers on Schönbein's method. In this case the sheet was soaked in the starch and hung up to dry in the usual way.

It may possibly be asked if a scale has been constructed to suit this new plan of preparing an ozone test. To this question, if asked, I should, at the present time, have to reply in the negative. The specimens on page 6 and on page 22 have somewhat the appearance of a scale in each case, but have not been prepared with that object. In those on page 6 the deposit is on paper. In those on page 22 the starch is deposited on thin microscopic covering glass, and both sets were prepared to give an opportunity of testing the result when the deposit is made on two such different substances. Those on the thin glass on page 22 are decidedly the best, and in constructing a scale I should use the glass as a basis for the deposit. The glass, too, has an additional advantage which I must not forget to name. In the lighter and, to some extent in the middle, tints, it is only the more superficial layers of starch that become tinted to the full extent that the amount of ozone will cause; whilst the deeper layers take on scarcely any colour. This difference can be seen and fairly estimated when glass is used, but in the paper process there is no possibility of properly estimating the difference in the tint of the deep and superficial layers, and this would be a matter of considerable importance in constructing a reliable scale.

Exhibited at the Meeting.

The plan I propose to pursue in constructing such a scale is to deposit a given weight of starch on glass of a certain area, and to charge this with the smallest amount of potassium iodide that will give a perceptible tint when the whole of the iodine has been liberated by the action of ozone. The next step will be to ascertain what increase in the re-agent will give such an increase in the depth of colour as will be plainly perceptible to the eye; and so to proceed until the whole scale has been completed. In this way a scale that will give some idea of the quantity of iodine liberated at each point may be constructed, and would be a perfectly natural scale. To carry this plan out in a careful and trustworthy manner will require more time than I have hitherto had at my disposal, but I hope at some not very distant period to have sufficient leisure to carry out the experiments.

In testing for ozone on the method usually followed a considerable portion of the ozone passes by unused. With a view of forming some idea what this amount is, I have constructed the flat glass tubes now exhibited. In the one case the starch is deposited on the glass and the other on paper. By passing a current of ozonised air through a series of these tubes the amount of ozone escaping can be ascertained with some degree of accuracy by its action on the starch in each succeeding tube.

In all that I have said above I have purposely avoided alluding to the vexed question of what other agents in the atmosphere are found to be capable of producing the same changes in the test papers that ozone brings about. That such agents do exist in the atmosphere at times all meteorologists agree; but, on the other hand, it is generally agreed that in some situations ozone is the principal, if not the only agent at work in producing these changes. It was with a view of determining for my own satisfaction the relative amount of ozone in the atmosphere at various points in the scale that the experiments above described were undertaken.

DISCUSSION.

THE PRESIDENT (Dr. Marcet) remarked that ozone was a difficult subject to deal with, and the paper just read would, he hoped, assist in the elucidation of the question.

Mr. WHIPPLE said that he regretted that ozone was so rarely observed now. He believed that if more thought and attention were given to the subject better results would be obtained. The test papers were usually exposed for a day, but during that time it appeared to be quite possible for indications obtained in the early part of the day to be entirely altered at some later hour. He suggested that it might be better to pass a measured volume of air over the paper. This could easily be accomplished by means of an aspirator. As regards the measurement of the intensity of the discolouration, it would be comparatively easy to devise a kind of tintometer by means of which the various shades could be accurately determined. The uncertainty hitherto attaching to ozone observations was largely due to the test papers not being freshly prepared, or being otherwise unsatisfactory. Dr. Blackley's method of preparing the test papers appeared to be a distinct advance on those previously in use. He hoped that ozone would become more generally observed, as, since Moffat's and Schönbein's time, nobody appeared to have devoted much thought or consideration to the question of its proper observation.

Results of Meteorological Observations made at Akassa, Niger Territory, February 1887 to October 1888.

By FRANK RUSSELL, F.R.G.S., an Officer for the Niger Territories.

(Communicated by Robert H. Scott, M.A., F.R.S.)

[Received February 20th. -Read May 15th, 1889.]

Akassa is the Seaport and principal Depôt of The Royal Niger Company, being situated at the mouth of the Nun River in the Niger Delta—upon an island bounded on its landward side by the Sengana River. Its position is long. 6° 20′ 10″ E. and lat. 4° 20′ 0″ N. The general character of the land in the neighbourhood is low and swampy, overgrown by mangrove trees.

The station lies in a clearing close to the sea shore, being but 3¼ miles from the river bar, and about 3 miles from Cape Nun. The river is 1¼ miles in width at the place. The Observatory is distant 120 yards from the dwelling-house—the nearest building to it—and about three times that distance from the nearest trees. It is in close proximity to water on the east and south, and the swampy flat on which it stands is occasionally quite submerged during heavy rains.

My equipment consists of the following instruments, by Troughton and Simms, London, with Kew certificates:—Standard Fortin barometer; standard thermometer; maximum (Negretti's) and minimum thermometers; dry and wet bulb hygrometer; radiation black-bulb maximum *in vacuo*; grass minimum; Howard 5-inch rain-gauge; Robinson anemometer—improved portable form; wind vane, plain but very sensitive; also one of Negretti's universally mounted sunshine recorders (glass sphere).

The exposure for shade consists of a Stevenson double-louvre screen, whose interior dimensions are—length 18 ins., height 15 ins., and breadth 11 ins., with double roof and ventilated bottom, standing 4½ feet from the ground. This extra height it is intended to reduce by adding a layer of soil a depth of 6 ins., bringing the level this much above its present wet one, so as to improve the drainage within a limited area of the thermometers. The screen opens to the North by a hinged door.

The solar radiation thermometer is fixed, at the same height, to a stand which consists of a wooden post, at the top of which its clip is secured. The grass minimum has a similar clip holder, fixed to a wooden block 6 ins. by 4 ins., painted black, so that the thermometer is thus held level with the top of the grass (*Cynodon*) which grows sparingly over the sandy soil. The sunshine recorder stands upon a brick pedestal, and is placed accurately in the meridian, at a height of 4½ ft. The rain-gauge is exposed, with the rim of

the receiver 1 foot above the ground, clear of all obstruction. The wind vane is fixed upon a pole at an elevation of 15 feet and the anemometer similarly at a height of 12 ft., with steps to enable the observer to take readings. The wind vane, I should add, is placed in true meridian line, and the cardinal points and subdivisions can be read off from the ground. The barometer is placed in my room in the dwelling-house, the cistern being 21 ft. above sea-level.

On leaving for England on furlough, without being able to arrange for a continuance of the observations during absence, I have dismounted the instruments, and they are now being re-tested at Kew. The records will be resumed on my return, probably about April or May 1889.

The Observatory is Astronomical as well as Meteorological, but as the telescope-house was only recently fit to receive the instruments, little progress could be made beyond a few preliminary adjustments for meridian mark, &c., with a large transit theodolite (also of Troughton's) with 8-inch circles. When everything is in working order I hope to fix the geographical position of this and other important points with more precision than at present obtains.

Barometer.—The accompanying summary gives the means deduced from two observations daily at the hours of 9 a.m. and 9 p.m.

During February 1887 extra observations at 1 p.m. and 5 p.m. were made, and with these the mean becomes 29·899 ins. as against 29·905 ins., difference 0·006 in. Occasional records have been taken at intervals of three hours, but for want of the night readings it is not possible to say certainly whether the mean would vary, or to what extent.

A self-recording aneroid was also used for some time; the instrument, however, for want of proper test, could not be depended upon; neither by comparison with the standard, for a constant error, nor for accuracy of the driving clock, which was found at the end of each week to lose about seventy minutes. It gives nevertheless a good general idea of the smallness of the fluctuations from hour to hour, also the apparent regularity of the daily maxima and minima, of which two are easily traced, occurring between the hours of 9 and 10 a.m. and 8 and 4 p.m.; the day maximum and minimum being more marked than the night.

The monthly inequalities have their greatest divergence in 1887, being 0·211 in., and 0·161 in. in 1888, greatest in July each year and least in March-April. The oscillation was greatest in May 1887—0·241 in., and least in July 1888—0·098 in.; the mean for the whole period of twenty-one months being 0·166 in. The greatest pressure registered was on June 29th, 1888—30·184 ins., and the least on March 23rd, 1888—29·800 ins.; the difference amounting to 0·384 in. The mean pressure is given as 29·987 ins.

Temperature.—The figures given in the Table are deduced from daily observations off the maximum and minimum thermometers. As, however, the hygrometric values are computed from the readings at 9 a.m. and 9 p.m., these dry bulb values are included for comparison.

The highest means are shown for the months of December, January to April, and the maximum for the year about the middle of April.

The lowest mean temperatures were during the months July to September, and the minimum for the year occurred about the end of August.

The difference between the maximum and minimum temperatures for each month is greater in the hot than in the cold months.

The mean temperature for August is 2°·7 below the mean for the twenty-one months under review, while that for April is 2°·0 above, and the mean temperature of these two months differs but 0°·3 from the general mean, 77°·9.

The highest temperature recorded in the shade was 92°·5 in February 1887, being 5°·5 over the average for that year and 6°·2 above the periodic mean. The lowest, 62°·9, occurred in May 1887, the difference from the means being 5°·4 and 6°·3 respectively. This reading, however, was on two occasions only exceeded by small amounts, viz. February 1° and August 1°·2.

Radiation.—The readings of the black-bulb thermometer *in vacuo* in the sun's rays give the following results:—During the sixteen months July 1887 to October 1888 inclusive, when observations have been regularly made, the highest recorded amount was 166°·4, in November 1887.

The lowest temperature on the grass for the same period was in August 1887, 57°·2. By combining these results we find the entire range to have been 109°·2.

The mean range for the entire period was 70°·5. The least mean daily range results in the month of June 1888, being 59°·9. The greatest range, 77°·0, was in April 1888.

Sunshine.—Records have been taken for the duration during the five months, June to October 1888, giving as result:—Highest per cent. 24·2 in the latter month, and lowest 10·4, as mean for July.

Vapour tension.—The greatest daily amount of range is shown by the observations for the month of April in each year, ·096 in. being recorded in 1887, and ·048 in. in 1888. The average is about a twelfth part of the mean for the month.

The observations for February point to a least amount of vapour being present in the air about sunrise, increasing up to an hour or two after noon, then decreasing until next morning, the mean diurnal variation amounting to about one-sixth of the average quantity present.

The results for the whole period under review indicate a least quantity in the air during the months of July and August, and greatest in March and April. The mean difference amounts to ·140 in., or about one-eighth part of the mean for the twenty-one months.

The mean percentage of relative humidity for the whole time stands at 87·7, that of the month of July is in greatest defect whilst January and October are each the greatest amount in excess.

Rainfall.—The total fall measured for the period of twenty-one months was 249 ins. on 381 rainy days, or 59 per cent. of the whole number involved.

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT AKASSA, NIGER TERRITORY, FEBRUARY 1887 TO OCTOBER 1888.

Months.	Barometer.				Temperature.							Radiation.				Sunshine.		Hygrometry.					
	Means.		Extremes.		Extremes.		Means.					Black Bulb in Sun.		Minimum on Grass.				Dew Point.		Relative Humidity.		Vapour Tension.	
	9 a.m.	9 p.m.	Highest Observed.	Lowest Observed.	Highest.	Lowest.	Max.	Min.	Mean.	9 a.m.	9 p.m.	Highest.	Mean.	Lowest.	Mean.	Total hours recorded.	Percentage of possible duration.	9 a.m.	9 p.m.	9 a.m.	9 p.m.	9 a.m.	9 p.m.
1887.	In.	In.	In.	In.	°	°	°	°	°	°	°	°	°	°	°			°	°	o/o	o/o	In.	In.
February	29·940	29·870	30·014	29·849	92·5	63·9	86·4	72·3	79·3	..	..	..	..	..	..	..	..	75·2	73·7	84·0	92·0	·877	·795
March ..	·945	·906	·014	·849	88·9	70·3	85·9	73·9	79·9	..	..	..	..	..	..	..	..	74·6	74·0	81·3	88·9	·860	·804
April	·893	·882	·033	·802	89·9	70·9	86·0	73·6	79·8	81·2	76·8	..	..	..	..	..	..	74·0	74·1	80·1	91·1	·844	·848
May	29·919	29·929	·045	·804	89·7	62·9	84·8	73·5	79·1	80·5	76·9	..	..	..	..	..	..	75·0	73·4	84·3	89·0	·869	·825
June ...	30·041	30·086	·078	29·970	85·3	69·7	81·3	73·7	77·5	76·5	76·1	..	..	..	..	..	..	72·4	71·6	83·8	85·3	·797	·778
July	·116	·080	·163	30·035	82·9	69·5	79·4	72·8	76·1	76·8	74·5	155·6	135·1	64·8	69·0	..	..	70·2	68·9	79·7	82·4	·741	·708
August ..	·059	·026	·145	29·963	84·0	64·1	79·6	70·8	75·2	76·1	73·1	157·2	139·8	57·2	66·5	..	..	69·5	68·9	80·0	86·0	·723	·707
September	·056	30·020	·100	·972	84·2	70·5	80·0	72·2	76·1	76·9	73·6	155·2	135·2	67·0	70·0	..	..	72·6	71·5	86·2	92·8	·801	·772
October ..	30·013	29·974	·053	·924	84·3	69·1	81·1	71·7	76·4	77·2	74·0	162·6	142·0	66·9	69·4	..	..	73·1	72·5	87·0	94·5	·816	·798
November	29·959	·936	·014	·894	86·0	70·4	82·9	72·6	77·7	79·9	75·3	166·4	145·8	67·0	70·1	..	..	74·4	73·3	83·5	93·0	·852	·821
December	29·960	29·948	30·020	29·868	89·9	70·4	84·9	72·9	78·9	81·6	76·4	159·6	145·8	67·0	69·9	..	..	75·3	73·9	81·0	91·0	·877	·837
Means for 11 months	29·990	29·969	..	..	87·0	68·3	82·9	72·7	77·8	..	..	159·4	146·0	64·9	69·1	..	..	73·1	72·3	82·8	89·6	·823	·790
1888.																							
January	29·971	29·958	30·048	29·887	88·0	68·3	85·1	72·9	79·0	80·6	75·6	156·9	141·5	64·3	69·0	..	..	77·1	75·0	88·0	97·0	·931	·868
February	·938	·926	29·987	·802	87·9	70·1	84·7	73·6	79·2	81·5	76·8	155·0	139·2	66·9	70·0	..	..	77·2	75·8	86·9	96·5	·936	·892
March ..	·959	·927	30·026	·800	88·6	69·1	85·3	74·2	79·8	82·5	77·9	157·7	145·1	66·1	71·0	..	..	77·3	76·1	84·5	94·0	·940	·902
April	·958	·922	·005	·871	88·0	70·8	85·9	74·5	80·2	82·5	78·2	162·3	148·9	69·0	71·9	..	..	77·0	76·2	84·7	93·2	·943	·905
May	29·977	29·944	·022	·860	88·7	72·3	83·7	74·5	79·1	81·2	77·4	155·3	138·8	69·2	72·1	..	..	76·6	75·7	85·5	93·7	·917	·888
June	30·060	30·034	·184	29·960	82·9	72·1	80·7	74·0	77·3	78·6	76·1	154·6	131·3	69·7	71·4	41·1	11·1	74·5	73·5	86·9	91·4	·853	·826
July	·110	·076	·143	30·045	82·0	71·4	79·6	73·2	76·4	76·8	75·1	152·7	130·4	68·2	70·1	41·9	10·4	72·2	71·0	85·7	87·0	·790	·758
August ..	·084	·046	·136	29·933	82·4	66·0	78·9	71·5	75·2	76·8	73·0	153·7	136·4	60·9	68·7	66·4	17·5	71·2	70·1	84·4	90·2	·765	·735
September	·050	30·007	·112	·941	83·8	70·2	80·8	73·1	76·9	77·9	75·0	159·5	144·3	68·0	70·4	48·9	13·3	73·7	72·6	86·5	92·1	·829	·799
October ..	30·008	29·967	30·073	29·895	84·9	70·2	82·3	72·7	77·5	79·1	75·3	161·1	143·0	66·6	69·3	88·9	24·2	74·4	73·2	86·0	92·9	·851	·816
Means for 10 Months	30·012	29·980	..	..	85·7	70·1	82·8	73·5	78·1	..	..	156·9	139·9	66·9	70·3	..	..	75·1	73·0	85·9	92·8	·875	·838

Results of Meteorological Observations made at Akassa, Niger Territory, February 1887 to October 1888.

Months.	Rain.				Wind Direction with Amount of Rain and No. of Days.																		Wind Velocity.				
	Total.	No. of Rainy Days.	Greatest Fall.	Date.	N.		NE.		E.		SE.		S.		SW.		W.		NW.		Calm.		Totals.		Amount in 12 hours.		Monthly Mean.		Daily Average per hour.
					Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Greatest.	Least.	Day.	Night.	
1887.	Ins.		Ins.			Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.	Miles.	Miles.	Miles.	Miles.	Miles.
February	7·000	10	2·430	22	..	..	2	1·73	1	·84	..	..	2	·68	4	1·33	..	..	1	2·43	..	..	10	7·00	..	..	..	..	..
March ..	10·135	10	3·500	20	..	..	3	·89	..	..	..	..	..	..	1	1·70	..	..	2	6·01	4	1·54	10	10·14	..	..	..	..	..
April	9·935	13	3·550	16	5	2·24	..	..	1	3·55	3	1·21	2	·54	2	2·39	.	..	..	..	..	..	13	9·93	..	..	..	..	..
May	19·140	15	4·080	22	1	1·01	2	2·09	..	..	1	·01	5	1·03	6	15·00	..	..	..	..	..	..	15	19·14	..	..	..	..	..
June	14·620	19	2·740	1	..	..	2	2·69	..	..	1	·36	6	4·47	8	5·23	..	..	..	..	2	1·87	19	14·63	..	..	..	..	..
July	3·285	12	1·910	5	..	..	..	..	..	..	..	..	9	2·99	3	·30	..	..	..	..	..	..	12	3·29	120·1	18·0	93·2	69·9	6·8
August ..	3·345	19	0·590	28	..	..	..	..	..	..	..	..	4	·77	8	1·26	5	1·07	..	..	2	·24	19	3·34	121·7	22·8	86·3	51·4	5·7
September	14·787	27	3·775	26	..	..	..	..	..	..	..	..	..	..	11	4·98	4	1·21	2	4·95	10	3·65	27	14·79	102·5	9·6	70·2	35·7	4·4
October ..	28·642	26	3·620	5	1	3·65	..	..	..	..	..	..	1	·91	8	11·72	..	..	..	..	16	13·32	26	28·64	123·6	63·8	63·5	27·9	3·8
November	18·210	20	3·660	30	..	..	4	4·71	1	·16	..	..	4	1·70	7	4·72	3	3·91	..	..	1	·01	20	15·21	107·2	11·9	65·7	30·9	4·0
December	6·185	15	1·780	27	..	..	..	..	..	..	..	..	1	·12	9	3·63	2	2·24	..	..	3	·20	15	6·18	97·5	0·6	66·3	34·9	4·2
Totals for 11 months	132·284	186	..	..	7	6·90	13	12·11	3	4·55	5	1·53	34	13·21	65	52·30	14	8·43	5	13·39	38	19·83	186	132·28	..	..	..	..	4·8
1888.																													
January	1·557	10	0·550	7	1	·03	1	·18	..	..	2	1·74	..	..	3	1·02	..	..	2	·16	3	·17	10	1·58	91·4	5·5	56·6	18·7	3·1
February	7·580	10	2·580	14	..	..	1	·91	..	..	..	..	..	..	2	3·35	1	·35	3	·96	1	·28	10	7·58	116·0	3·1	71·6	28·6	4·2
March ..	8·995	11	2·610	21	1	·35	3	5·25	..	..	..	..	1	·22	3	1·17	..	..	2	1·96	1	·04	11	8·99	117·3	10·0	79·2	37·6	4·8
April	8·239	18	1·950	25	..	..	3	1·83	..	..	1	·07	..	..	7	3·64	2	·74	..	..	5	1·96	18	8·24	156·8	10·7	83·7	34·3	4·9
May	18·490	20	5·905	27	..	..	3	3·32	1	5·91	2	1·18	1	·18	9	6·52	..	..	..	..	4	1·28	20	18·49	122·8	22·1	79·7	43·6	5·1
June	19·475	28	4·030	10	..	..	1	·70	..	..	..	..	..	..	18	9·87	1	·52	1	·34	7	7·04	28	19·47	111·1	15·2	75·9	52·9	5·3
July	10·541	25	1·650	6	..	..	..	..	..	..	..	..	..	..	15	5·92	1	1·06	1	·34	8	4·22	25	10·54	105·2	13·2	78·0	52·2	5·4
August ..	6·425	19	1·320	3	1	·19	..	..	..	..	..	..	..	..	7	2·21	1	1·11	..	..	10	2·91	19	6·43	123·0	15·5	78·5	46·9	5·2
September	8·871	29	1·460	24	..	..	..	..	..	..	..	..	..	..	12	5·52	1	1·22	..	..	16	2·14	29	8·87	197·0	8·2	85·0	40·6	5·2
October ..	26·448	25	3·965	11	..	..	..	..	1	·20	1	1·11	1	1·29	6	5·25	..	..	1	·13	15	18·46	25	26·45	102·7	12·8	68·2	27·4	4·0
Totals for 10 months	116·618	195	..	..	3	·57	12	12·19	2	6·11	6	4·10	3	1·69	82	44·57	7	5·00	10	3·89	70	38·51	195	116·62	..	..	..	..	4·7

The months which combined contributed the larger number of wet days in the total were June and July in each year, 47 and 37 respectively; August, 38; September, 56; and October, 51. Those of least number were December, January, February, and March.

The periods of highest rainfall are shown as having been the Octobers, 55 ins.; Mays, 37½ ins.; and Junes, 34 ins.

The annexed list gives the dates in each month of greatest fall in twenty-four hours:—The heaviest showers recorded occurred on May 27th, 1888, 5·90 ins. in 5½ hours, wind East; April 16th, 1887, 3·55 ins. in 10½ hours; and on February 14th, 1888, 2·58 ins. in 8 hours. These were all accompanied by electrical disturbance and winds of greater or less force.

Of the total rainfall the highest percentage, both in respect of frequency and quantity, was due to South-west winds; the next value being with calms or Southerly winds. The tabulated summary gives 55·6 per cent. due to SW, W, NW, N winds, and 22·0 per cent. due to NE, E, SE, S winds.

Fogs, Mists, &c.—In an atmosphere so highly charged with moisture, relatively, these phenomona were prevalent in variable intensity at all times of the year. During the early months of December 1886, January-February 1887, the North-easterly and Harmattan winds contributed their mixture of fine dust with mist caused by evaporation; from May to November, the effect of condensation, from a mixture of fresh water of variable temperature brought down by the first rising river, with the sea, is observable. Nightly mists are set up by radiation; and although fogs may not always precede, they invariably follow heavy rains.

Electrical Disturbances.—Thunderstorms were of frequent occurrence. The months in which they prevailed most frequently were March, April, and May. Some unusually heavy thunderstorms happened also in October and November.

Winds.—The velocity of the wind has only been taken instrumentally, at daily periods, from July 1887 to October 1888. The average per hour is given in the Table. The highest amount recorded during 12 hours, 9 a.m. to 9 p.m., was 197 miles in September, and the lowest during the night, 9 p.m. to 9 a.m., December, 0·6. The mean velocity per hour for the days was 8·1 miles, and the nights 1·6 miles; the movements, however, being most rapid from 10 a.m. to 4 p.m. daily.

Tornados have been rather frequent, but of limited violence. These occur at the change of seasons, both before and after "Harmattan." To judge from the amount of destruction to shipping on the West Coast, the month of May would show the highest record. They may, however, spring up at other times, especially during a period of great heat, this being one of the most usual indications of their approach. As the storm is forming, there appear certain other premonitory symptoms, not the least remarkable being an oppressive stillness of the air; not a movement of leaf or blade of grass, as every living creature, instinctively anticipating some unusual occurrence, betakes itself to secure shelter: even the persistent insect life disappears, with the clamour of frogs and grasshoppers, and a silence at once unnatural and awe-inspiring ensues.

The sky, previously of clear and dazzling blue, is shrouded in a brownish dingy haze, thickening down on that part of the horizon from which the storm is approaching into clouds of sombre black, which now assume an arched shape, disclosing an under-cloud of grey, that by comparison seems almost white. This lighter coloured part accompanies the wind, the heavy black cloud being driven before it, and according as this arch is more or less distinctly defined, the force of the storm may be estimated. When much rain is also being discharged, the edge assumes a ragged and changeable form, and the storm is probably much modified by the time it reaches us.

The more rain the less wind appears to hold good in these cases. The temperature now begins to fall rapidly as the first breath of cool air is felt, and laden as it is with the malodorous effluvia of swamp and bush, is very liable to cause ague symptoms unless extra clothing is put on. Sharp peals of thunder, followed by vivid flashes of lightning in quick succession, are the accompaniment to the deepening roar of the fast approaching storm as clouds of sand and detritus are borne along by it. In a moment more it is upon us with resistless fury, threatening universal extermination; the earth seems to tremble with the detonations of thunder, whilst the lightning hisses and sputters as it wraps everything in its lurid light; the effect being heightened by the gathering darkness and the downpour of rain, by which it is reflected as by countless prisms.

When the height of the storm has passed, usually in about twenty minutes, the rain may continue for many hours; the thunder and lightning working round all points of the compass; and it has happened that the wind also, gathering fresh force, returns from the opposite direction.

At sea, the usual South-easterly set of current is often changed by the wind's force, and this is taken advantage of by vessels bound to windward—along the Bight coast—lasting for a day or two.

As the effect of a storm blowing from seawards, the coast-line being low and flat, the water has been raised sufficiently high to overflow it, boats and canoes being carried 50 yards or more inland, whilst other objects of greater fixity have been buried in sand to a depth of 2 or 8 feet.

There is little wonder that the African householder contents himself with a dwelling of the smallest possible elevation, even at the expense of such necessities as daylight and fresh air as his frail structures would otherwise be in imminent peril of being carried away. As it is, the most serious calamity amounts to the loss of some part of a roof.

The character of the lightning partakes more of the "chain" than "forked." In some instances it is reported as being the cause of ignition to grass buildings. Certainly trees bear indications of being struck by it; but, on the other hand, I have never heard of a similar catastrophe happening to human beings or cattle, nor does the average native appear to recognise any special risk in this direction.

DISCUSSION.

Dr. LAWSON said that he had frequently experienced tornados similar to those described in the paper at Sierra Leone, but they had usually not been so intense as they appeared to be at Akassa. The arch referred to was very clearly defined, and as it approached the ascension of vapour in front could be distinctly seen. When the arch got overhead sudden gusts were experienced. On one occasion he had observed the barometer fall as much as 0·1 inch in less than five minutes, and this was immediately followed by a great gust of wind which damaged part of the roof of the house. The storms continued to blow off the land for a considerable time. They usually came on in the afternoon or at night, and were accompanied by a good deal of lightning and plenty of rain. After the storm had passed the wind remained Easterly. The men of war stationed at Sierra Leone were accustomed to shorten all sail except the foretop-mast staysail and run before the wind, vessels that did not shorten sail were in danger of being capsized.

THE CLIMATE OF BRITISH NORTH BORNEO.

By ROBERT H. SCOTT, M.A., F.R.S.

[Received May 7th—Read June 19th, 1889.]

More than seven years have now elapsed since a Charter was granted to the British North Borneo Co., November 1st, 1881, and it may therefore be of interest to the Society to hear what has been done since that time in the way of recording the climate of the Territory.

As regards the area, and the physical geography of the district, the *Handbook of British North Borneo*, prepared for the Colonial and Indian Exhibition of 1886, gives some particulars, from which the following notes are extracted.

"The territory of British North Borneo includes the northern portion of the great island of Borneo, from the Sipitong stream on the west to the Sibuku river on the east, and is coterminous with the northern boundary of the Sultanate of Brunei, on the west coast, and approaches that of the Netherlands possessions on the east. It is, roughly speaking, of pyramidal form, the apex being towards the north, the China Sea washing its western, and the Sulu and Celebes Seas its eastern coasts.

"The Sibuku boundary is in about lat. 4° 5′ N, the Sipitong boundary in lat. 5° 6′ N, while the boundary extends to the north as far as lat. 7° 25′ N. Gura Peak, in lat. N 3° 52′, is taken to be its extreme southern limit inland. The most westerly point is that of Kalias, long. 115° 20′ E, and the most easterly, Hog Point, 119° 16′ E. Its area, exclusive of islands, is computed at 30,403·87, and with the islands, 31,000 square miles."

As regards the mountains, the same authority states:—

"The courses of the mountain ranges have not yet been laid down with any attempt at accuracy in the published maps.

"It may be stated generally that there is a backbone range, which, commencing in the great mountain of Kinabalu (13,700 ft.), 52 miles from the northern extremity of the island, runs in a south-westerly direction through the territory. The range is much nearer to the west than to the east coast, with the result that

the rivers on the west are inferior in length to those on the east side, though the scenery is grander and the coast more indented with bays and inlets. Kinabalu itself rises within some 25 miles of the west coast; and this may be taken to be the average breadth of the coast between the backbone range and the sea. From this range, which has a height of from 5,000 to 13,700 ft., many ridges are given off at right angles, and these in many cases are connected by cross ridges running north and south. These ridges, as a rule, rise abruptly from the plains, and are steep and narrow.

"In addition to this range, and between it and the sea on the west, is what is known as the Coast Range, running parallel to it from somewhat to the north of Gaya to the southward, and with a height of between 3,000 and 4,000 feet.

"Borneo differs from all the other large islands of what Wallace terms Australasia in not possessing a single volcano, either active or extinct."

As regards the climate, the *Handbook* contains a report by Dr. James Walker, the principal medical officer of the Government, from which I have extracted certain paragraphs of a general nature. In the original the remarks refer mainly to Sandakan, and the observations close with March 1886. I shall therefore merely quote the general remarks on the seasons.

"The North-east Monsoon commences about the middle of October, and continues till about the middle of April.

"During the greater part of this time the wind blows steadily and with moderate strength from the North and East.

"In the course of this Monsoon, particularly in December and January, there are generally one, two or three moderate steady gales, lasting from three to nine days. At other times the wind is a moderate breeze from about 11 a.m., getting rather stronger towards evening, and dying away in the early morning, when it may be overcome by a gentle land breeze. At the beginning and ending of the Monsoon the wind is not so strong or so steady, and the land breeze continues till later in the forenoon.

"The South-west Monsoon lasts from about the middle of April till the middle of October. The wind, as a rule, is not so strong nor so long-continued as in the North-east Monsoon. On the other hand, there are frequently squalls in the afternoon and evening, lasting for an hour or two, and sometimes blowing with the strength of a "fresh gale." Neither in this Monsoon, nor in the North-east, does the wind rise to the strength of a storm, or even of a "whole gale."

"The true wet season occurs (at Sandakan) in the North-east Monsoon, and includes the months of November, December, and January, and generally part of October or February or both. During this wet season the greater part of the rain falls as general rain from a uniform dull grey sky, and is pretty equally distributed between day and night. This wet season does not, however, come up to what seems to be commonly understood at home by that expression—of incessant rain for weeks or months. (Dr. Walker says:) I have never known the rain to continue without interruption for more than 48 hours; and in an average year there are not more than six or eight days on which rain falls for the whole 24 hours.

"The true dry season immediately follows this true wet season, and includes March and April, and generally the whole of May and part of February. During this time, any rain that falls generally occurs in showers during the night and early morning. There has been no month without several showers, and even in 1885, when there was an exceptionally severe drought both here and in the Straits during March and April, there was rain on 6 days in March and on 10 in April, while during these two months of the most severe drought yet experienced here there was a rainfall of 1·35 inches.

"This true dry season is followed by a period of moderate rainfall, commencing generally about June. The first month or six weeks of this period almost deserves to be called a second wet season, and the rest of the period up to the commencement of the true wet season might be described as the second dry season. As, however, the boundaries of these two are ill-defined, their characters similar, and the difference in rainfall comparatively small, it is better to consider them together, as a

sort of intermediate season. During this period the rain falls chiefly in heavy squalls (either with thunder or from thundery looking clouds), occurring most frequently in the afternoon and evening, but not confined to that time; and it is during these rain squalls that the heaviest falls of rain occur."

The Instrumental Meteorological Records.

In January 1882 an outfit of Meteorological Instruments was supplied by the Meteorological Council to Nav. Lieut. E. R. Connor, for the *Banshee*, a steamer in the service of the North Borneo Co. These instruments were subsequently returned to the Office, and I am not in possession of any information as to which, if any, of the observations now submitted have been made with them.

No records of any value are available for barometrical pressure, for the mercurial barometer supplied by us in 1882 has been returned to London, and the only record of pressure is that furnished by an automatic aneroid, which is seriously out in its setting.

The Charts of the Mean Barometric Pressure over the three Oceans, lately published by the Meteorological Office, give the following figures for the vicinity of the North point of Borneo.

Month.	Pressure. Ins.	Approximate No. of Observations.
February	29·91	215
May	29·88	90
August	29·87	50
November	29·88	100

The range of the readings throughout the year is therefore insignificant, and the greatest range shown by the charts in any of the months is 0·2 in. in February.

The observations subjoined have all appeared in the *Handbook for British North Borneo*, prepared for the Colonial and Indian Exhibition of 1886, and subsequently in the monthly numbers of the *North Borneo Herald;* and the present summary closes with the year 1888. The observations have all been made under the supervision of Dr. J. H. Walker, the principal Medical Officer of the Colony. The following are the particulars of the different stations extracted from the *Herald*, the names of the observers refer chiefly to the year 1887.

I shall commence with the most Southern Station on the East coast, and proceed round by the North to the extreme West point, opposite Labuan.

The latitudes are all N. and the longitudes E.

East Coast.

Silam.—Long. 118° 12′, lat. 5° 0′. The station is a few feet above sea-level, and distant a little over 100 yards from the beach.

The observer was Mr. Callaghan, and, during his frequent absences, his Malay clerk. Dr. Walker expresses his distrust of these observations.

Sandakan.—Long. 118° 12′, lat. 5° 49′. The station is 10 feet above sea-

level, and distant a little over a quarter of a mile from high water mark. The observer was the hospital dresser, under Dr. Walker's own supervision. The observations are of good quality except those of wind, which are affected by local circumstances.

North Coast.

Kudat.—Long. 116° 52′, lat. 6° 54′. The station is 50 feet above sea-level, and distant about a quarter of a mile from the beach. The observers are Messrs. Wheatley and Dunlop.

Limbuak, on Banguey Island, off the North point of Borneo.—Long. 117° 5′, lat. 7° 15′. No particulars are given of the station. The observer is Mr. Martens.

West Coast.

Gaya.—Long. 116° 5′, lat. 6° 0′. This is a small island off the coast. The station is 50 feet above sea-level, and about 100 yards from the beach. The observer was Kiteh, a Malay clerk, under the supervision of Mr. Haynes.

Papar.—Long. 115° 52′, lat. 5° 45′. The station is about 15 feet above sea-level and 2 miles from the beach. The observers were the Messrs. Wheatley.

Mempakol.—Long. 115° 25′, lat. 5° 16′. This is just opposite Labuan. The station is only a few feet above sea-level and close to the beach. The observer was at first Mr. Daly, subsequently Mr. Francis.

For the actual examination of the printed values which are not identical in the different publications above indicated, which is all the discussion which has been attempted, and for the arrangement of the material in the form of tables, I am indebted to Mr. J. A. Curtis, who has had considerable experience in work of that character.

For Sandakan we are able to submit fairly complete returns for the years 1887 and 1888, but for the other stations the records are so fragmentary that it seems best merely to give tables of mean monthly extremes of temperature and of rainfall.

As regards absolute extremes of temperature, Sandakan had a maximum of 95°·0 in April and May 1885, and a minimum of 67°·5 in January 1886. Kudat had a maximum of 98°·0 in January and December 1886, and Limbuak one of 99°·0 in January 1886. The last-named station had also the lowest minimum I can find, 66°·0 in February 1886.

As regards the rainfall, the returns are more complete than those of temperature. For Sandakan 10 years are available, with the single exception of the month of July 1879. For Silam there are 6 years with a few exceptions. The returns of "days of rain" are not always given.

The rainy season on the East coast is in the months from November to January, with a slight secondary maximum in June, as already mentioned in the remarks by Dr. Walker quoted at the commencement of the paper. The rainfall at Sandakan is much heavier than that at Silam.

The returns from the stations on the North and West coasts are very

SANDAKAN.

LONG. 118° 12′ E. LAT. 5° 49′ N. HEIGHT ABOVE MEAN SEA LEVEL 10 FEET.

1887.	Air Temperature.									Tension of Vapour.			Relative Humidity.		
	Dry Bulb.			Wet Bub.			Mean of Max. and Min.	Means of							
	9 a.m.	3 p.m.	9 p.m.	9 a.m.	3 p.m.	9 p.m.		Min.	Max.	9 a.m.	3 p.m.	9 p.m.	9 a.m.	3 p.m.	9 p.m.
	°	°	°	°	°	°	°	°	°	In.	In.	In.	o/o	o/o	o/o
January	80·2	82·0	77·3	77·2	78·2	75·8	78·6	73·7	83·4	·873	·887	·861	85	81	91
February	80·4	82·1	77·5	76·9	77·2	74·7	78·6	74·3	82·9	·855	·837	·806	83	77	85
March ..	80·7	82·3	77·6	77·2	77·5	75·7	78·7	73·3	84·0	·864	·848	·852	82	77	90
April	82·5	84·3	78·3	78·2	78·7	76·4	79·9	74·6	85·2	·876	·870	·872	79	74	90
May	83·4	85·5	78·3	79·4	79·4	76·1	80·8	74·6	87·0	·918	·884	·857	80	72	89
June	80·6	84·3	77·4	77·1	78·7	75·6	80·0	73·8	86·1	·861	·870	·850	83	74	90
July	81·7	87·5	78·8	77·4	79·5	76·5	81·1	74·3	88·0	·855	·852	·869	79	65	89
August ..	80·7	85·5	77·0	76·4	78·0	75·0	80·2	73·4	87·0	·826	·817	·829	79	66	89
September	81·4	87·1	77·6	76·9	79·4	75·3	80·6	73·5	87·7	·837	·854	·832	78	67	88
October ..	82·1	84·8	77·8	77·5	78·1	75·1	80·6	73·9	87·2	·852	·834	·819	78	69	86
November	81·3	84·4	77·7	77·2	78·4	75·5	80·4	74·4	86·3	·853	·853	·840	80	72	88
December	79·6	81·3	77·2	76·8	77·1	75·5	78·8	73·7	83·8	·866	·848	·849	86	80	91
Year ..	81·2	84·3	77·7	77·4	78·4	75·6	79·9	74·0	85·7	·861	·855	·845	81·0	72·8	88·8

1887.	Amount of Cloud.			Rainfall.			No. of Days of Rain.	Wind, No. of Observations of							
	9 a.m.	3 p.m.	9 p.m.	Total.	Max.	Day.		N.	NE.	E.	SE.	S.	SW.	W.	NW.
				Ins.	Ins.										
January ..	..	..	..	29·350	14·47	9th	?	17	17	0	4	9	12	12	22
February ..	..	..	..	18·305	..	..	?	7	3	0	2	5	19	26	22
March	..	..	..	12·950	..	..	?	1	3	1	11	5	44	5	23
April	..	..	..	5·265	..	..	19	1	3	3	18	6	33	7	19
May	..	..	..	2·555	..	..	7	3	4	2	25	18	22	9	10
June	..	..	..	5·560	..	..	14	0	3	0	36	1	33	2	15
July	3·9	4·6	5·0	4·480	..	..	18	0	3	4	38	3	31	2	12
August	5·6	6·3	5·5	6·330	1·07	14th	18	0	10	0	32	5	28	2	16
September..	6·2	6·7	7·8	12·270	..	..	?	0	0	2	43	1	25	1	18
October	3·9	5·2	4·9	9·180	..	..	15	0	6	0	36	2	33	1	15
November ..	6·7	7·1	6·5	8·760	..	..	17	0	2	0	23	0	45	1	19
December ..	6·5	7·1	5·6	32·470	7·60	26th	26	1	5	0	12	1	38	0	36
Year.....	..	..	..	147·475	..	..	216	30	59	12	280	56	363	68	227

NOTE.—The wind direction must be accepted with reserve, owing to the position of the station.

scanty, but I have fortunately been able to find, at the Colonial Office, returns of rainfall for Labuan for 11 years (irregular) and for Sarawak for 5 years.

Labuan is, as already stated, opposite Mempakol. Its rain returns show a totally different distribution to that at Sandakan, with a strongly marked minimum in February, while there is no decided maximum, the falls in May, August, October, and November ranging between 15·18 ins. in August and 14·06 ins. in November.

The returns for Labuan are very irregular. We have the years 1855-1858,

SANDAKAN.

LONG 118° 12′ E. LAT. 5° 49′ N. HEIGHT ABOVE MEAN SEA LEVEL 10 FEET.

1888.	Air Temperature.									Tension of Vapour.			Relative Humidity.		
	Dry Bulb.			Wet Bulb.			Mean of Max. and Min.	Means of							
	9 a.m.	3 p.m.	9 p.m.	9 a.m.	3 p.m.	9 p.m.		Min.	Max.	9 a.m.	3 p.m.	9 p.m.	9 a.m.	3 p.m.	9 p.m.
	°	°	°	°	°	°	°	°	°	In.	In.	In.	o/o	o/o	o/o
January ..	78·9	82·0	77·4	75·9	76·5	75·0	78·7	73·9	83·4	·837	·808	·821	85	74	87
February	81·4	83·3	78·3	76·8	76·5	74·8	79·2	74·1	84·2	·833	·783	·796	77	69	82
March ..	83·3	85·4	79·3	78·2	78·0	75·8	80·7	74·8	86·6	·861	·819	·825	76	66	82
April	85·0	86·8	82·2	79·6	79·7	77·2	83·1	76·3	89·9	·902	·875	·835	74	69	76
May	84·8	87·5	80·7	79·2	79·0	77·5	84·0	76·5	91·4	·886	·828	·879	74	63	84
June	81·7	88·7	79·7	77·9	79·8	76·9	82·2	75·0	89·4	·879	·843	·869	82	62	86
July	82·1	88·9	80·4	77·1	79·4	76·3	82·6	75·7	89·4	·833	·821	·827	76	60	80
August ..	83·0	88·6	79·7	77·8	79·0	76·3	82·6	74·9	90·3	·847	·808	·840	75	59	83
September	83·3	87·8	78·6	78·1	79·1	76·1	81·5	74·3	88·6	·856	·828	·851	75	68	88
October ..	83·5	86·4	78·2	78·5	78·6	76·6	82·3	75·1	89·4	·873	·830	·882	76	65	91
November	82·7	86·0	79·0	78·6	79·1	76·7	81·3	74·8	87·7	·891	·860	·873	80	68	89
December	82·6	84·7	79·0	78·5	78·7	76·5	80·8	75·3	86·2	·889	·864	·863	81	72	88
Year....	82·7	86·3	79·4	78·0	78·6	76·3	81·6	75·1	88·0	·866	·831	·847	77·6	65·8	84·7

1888.	Amount of Cloud.			Rainfall.	No. of Days of Rain.	Prevailing Direction of Wind.
	9 a.m.	3 p.m.	9 p.m.	Total.		
				Ins.		
January.....	7·0	6·0	4·0	11·03	21	SW
February	6·0	5·0	5·0	1·90	11	NW
March	5·0	3·0	2·0	3·99	11	NW
April .....*	2·0	5·0	1·0	1·86	5	NW
May	2·0	3·0	1·0	2·82	10	NW
June	5·0	5·0	5·0	9·29	15	NW
July	5·0	5·0	5·0	3·18	9	SE
August	3·0	3·0	4·0	11·81	17	SW
September....	3·0	3·0	6·0	13·36	17	SW NW
October	2·0	3·0	5·0	9·40	13	SW NW
November	3·0	3·0	3·0	13·50	9	NW
December	5·0	5·0	4·0	19·52	19	NW
Year	4·0	4·1	3·8	101·66	157	..

inclusive, complete, then there is a gap of 20 years, from which time the yearly totals are given, but not the monthly values for 1883 and 1884.

For Sarawak we have five years nearly complete. For several months no record of the days of rain is given, and for January 1885 there are no data. The means are for five years except in the case of January.

The station is much nearer the Equator than is Labuan, and the distribution of the fall is strongly contrasted with that prevailing at that station, and very closely resembles that at Sandakan.

I have appended to the paper the mean results for other stations in Borneo, taken from the latest volume (for 1887) of *Regenwarnemingen in Nederlands Indië*, by Dr. J. P. Van der Stok, director of the observatory at Batavia. The number of years is 9, except where otherwise stated.

MEANS OF MAXIMUM AND MINIMUM TEMPERATURES.

North Borneo.—Sandakan.

Date.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.		Year.		Date.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	
1879	82·0	..	80·9	..	84·3	..	85·6	..	86·6	..	86·1	73·2	86·3	74·4	85·6	73·1	88·3	75·0	86·7	74·5	87·4	75·3	84·7	74·0	85·4	..	1879
1880	83·3	73·1	86·7	74·7	87·1	74·1	88·1	74·2	90·5	74·8	88·5	73·4	89·9	73·5	90·8	74·0	89·7	73·5	90·1	73·7	85·7	73·6	83·7	71·7	87·8	73·7	1880
1881	82·3	73·6	83·7	72·7	84·9	74·1	85·6	74·6	88·2	74·4	87·3	73·6	88·3	73·6	88·5	71·7	..	..	..	..	..	..	..	..	..	..	1881
1882	89·3	73·7	87·0	73·8	87·9	73·9	90·0	74·9	91·6	74·8	89·8	73·6	89·3	73·3	91·0	72·8	90·7	74·7	90·4	74·1	88·0	73·9	88·4	73·6	89·5	73·9	1882
1883	87·4	73·2	87·2	73·9	89·3	74·7	90·5	75·1	89·6	74·9	89·2	74·7	91·0	74·6	89·9	73·8	90·3	73·9	89·5	72·8	88·1	73·8	85·8	71·5	89·0	73·9	1883
1884	85·2	72·1	85·8	72·3	87·8	73·0	88·7	73·9	88·3	73·4	87·8	72·3	87·6	72·4	89·1	72·3	88·0	72·1	88·3	72·7	87·5	73·0	86·4	72·2	87·5	72·6	1884
1885	89·5	72·8	87·7	73·3	89·9	73·3	92·7	74·8	93·0	74·7	90·9	72·5	90·3	71·9	89·0	73·3	88·7	72·9	88·4	72·4	87·6	72·6	86·1	72·6	89·5	73·1	1885
1886	84·3	71·6	84·5	71·8	86·9	72·1	88·6	72·9	89·4	74·8	87·7	73·8	88·3	73·2	88·9	73·7	89·2	73·7	87·8	75·5	86·4	72·9	83·6	71·4	87·1	72·9	1886
1887	83·4	73·7	82·9	74·3	84·0	73·3	85·2	74·6	87·0	74·6	86·1	73·8	88·0	74·3	87·0	73·4	87·7	73·5	87·2	73·9	86·3	74·4	83·8	73·7	85·7	74·0	1887
1888	83·4	73·9	84·2	74·1	86·6	74·8	89·9	76·3	91·4	76·5	89·4	75·0	89·4	75·7	90·3	74·9	88·6	74·3	89·4	75·1	87·7	74·8	86·2	75·3	88·0	75·1	1888
Mean 9 years	85·3	73·1	85·5	73·4	87·2	73·7	88·8	74·6	89·9	74·8	88·5	73·6	89·1	73·6	89·4	73·3	89·0	73·7	88·6	73·9	87·2	73·8	85·4	72·9	87·8	73·7	Mean 9 years

Silam.

	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	
1886	..	..	..	..	..	..	..	..	..	..	..	..	85·6	72·6	..	..	..	..	..	..	85·1	71·7	84·8	71·7	..	..	1886
1887	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1887
1888	85·4	73·8	86·9	73·0	87·7	71·8	85·6	72·0	85·9	72·4	85·7	71·4	85·2	71·4	85·5	70·0	85·3	70·0	85·9	70·4	87·0	70·4	86·3	71·1	85·0	71·5	1888

Kudat.

	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	
1882	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85·1	76·2	84·3	75·0	..	..	1882
1883	83·7	75·7	85·1	75·5	87·3	77·2	88·3	78·0	88·6	76·4	88·5	75·9	88·6	75·4	89·3	75·5	88·4	75·2	87·6	75·2	83·6	75·1	81·5	73·7	86·7	75·7	1883
1884	81·0	74·2	84·6	74·6	81·9	75·6	88·4	75·8	90·0	76·1	89·7	74·1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1884
1885	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1885
1886	81·9	71·0	82·4	72·8	84·7	74·1	88·1	75·6	89·8	73·4	90·1	75·2	92·3	76·3	91·5	74·2	89·6	76·7	87·8	77·4	85·6	72·9	81·4	72·3	87·1	74·3	1886

MEANS OF MAXIMUM AND MINIMUM TEMPERATURES.

North Borneo.—Limbuak-Banguey.

Date.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.		Year.		Date.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
1886	86·6	73·2	85·9	70·7	87·1	71·5	88·2	74·5	88·4	75·8	87·5	74·4	87·0	75·8	88·0	75·0	87·3	72·9	..	..	..	..	..	..	..	..	1886
Papar.																											
1882	84·0	72·0	83·0	70·0	84·0	73·0	85·0	73·0	87·0	74·0	86·0	73·0	86·0	74·0	85·0	73·0	82·0	70·0	79·0	70·0	82·0	72·0	79·0	72·0	83·5	72·1	1882
1883	82·0	73·0	81·0	73·0	83·0	73·0	85·0	74·0	84·0	74·0	84·0	74·0	85·0	73·0	86·0	72·0	89·0	70·0	..	..	..	..	..	..	..	..	1883
1884	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1884
1885	81·9	71·0	81·3	70·6	81·7	71·8	85.1	74·8	85·6	74·7	85·6	74·5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1885
1886	..	..	..	..	..	..	85·3	74·5	..	75·3	83·9	74·3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1886
1887	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	86·6	75·2	85·7	74·8	84·7	74·7	..	..	..	..	1887
1888	..	..	..	..	85·2	73·7	..	..	..	..	87·9	75·6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1888
Gaya.																											
1887	..	..	..	..	..	..	..	..	..	..	..	..	87·7	74·9	..	..	86·9	75·7	85·2	75·2	83·5	73·9	..	..	..	..	1887
1888	82·8	73·3	..	..	84·7	75·6	86·9	77·4	..	..	86·8	76·4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1888
Mempakol.																											
1886	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	88·5	75·7	87·6	75·6	85·9	74·8	..	..	1886

RAINFALL.—Total for Month, with Number of Rainy Days.

North Borneo.—Sandákan.

Date.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		October.		Nov.		Dec.		Year.		Date.
	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	
	In.		In.		In.		In.		In.		In.		In,		In.		In.		In.		In.		In.		In.		
1879	14·92	..	21·95	..	21·35	..	7·74	..	4·36	..	2·65	..	2·67	..	4·92	..	2·08	..	10·88	..	8·18	..	12·29	.	113·99	..	1879
1880	22·73	..	5·07	..	10·57	..	8·71	..	6·72	..	5·73	..	6·37	..	17·88	..	11·60	..	8·77	..	26·40	..	26·59	..	157·14	..	1880
1881	14·21	..	9·09	..	1·54	..	4·47	..	10·09	..	11·23	..	6·66	..	4·91	..	19·18	..	3·78	..	24·05	..	10·00	..	119·21	..	1881
1882	31·28	..	7·50	..	8·89	..	9·31	..	2·82	..	15·50	..	7·05	..	4·90	..	5·20	..	8·40	..	19·30	..	13·80	..	133·95	..	1882
1883	18·70	..	16·70	..	9·06	..	3·82	..	9·36	..	4·65	..	10·03	..	3·80	..	8·49	..	12·76	..	13·76	..	23·57	.	134·70	..	1883
1884	16·68	..	5·06	..	3·60	..	0·77	..	9·08	..	7·87	..	7·68	..	6·60	..	6·92	...	9·83	..	16·58	..	15·52	..	106·19	..	1884
1885	5·72	11	1·99	11	0·84	6	0·51	10	3·13	8	17·11	20	5·29	10	8·84	18	8·43	16	16·73	16	12·28	20	20·37	22	101·24	168	1885
1886	30·72	22	4·96	16	3·60	7	0·64	8	5·50	12	7·28	20	3·49	19	4·18	16	14·26	20	6·50	23	14·12	22	28·07	25	123·32	211	1886
1887	29·35	?	18·31	..	12·95	..	5·27	19	2·56	7	5·56	14	4·48	18	6·33	18	12·27	?	9·18	15	8·76	17	32·47	26	147·49	..	1887
1888	11·03	21	1·90	11	3·99	11	1·86	5	2·82	10	9·29	15	3·18	9	11·81	17	13·36	17	9·40	13	13·50	9	19·52	19	101·66	..	1888
Total	195·34	..	92·53	..	76·39	..	43·10	..	56·44	..	86·87	..	56·90	..	74·17	..	101·79	..	96·23	..	156·93	..	202·20	..	128·89	..	Total
Mean	19·53	..	9·25	..	7·64	..	4·31	..	5·64	..	8·69	..	5·69	..	7·42	..	10·18	..	9·62	..	15·69	..	20·22	..	123·89	..	Mean
Silam.																											
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1883	9·85	..	7·89	..	5·19	..	3·18	..	16·56	..	7·45	..	4·91	..	4·30	..	10·32	..	5·05	..	8·79	..	10·04	..	93·53	..	1883
1884	6·45	..	7·05	..	2·03	..	3·85	..	4·95	..	..	..	3·86	..	3·13	..	11·14	..	9·06	..	13·70	..	26·48	..	..	..	1884
1885	2·61	4	0·00	0	0·40	1	1·04	2	7·70	5	18·80	11	7·81	4	2·40	2	5·80	3	6·41	6	10·39	6	11·01	7	74·37	51	1885
1886	19·56	11	1·93	2	4·66	4	2·05	9	7·31	12	7·65	13	5·25	17	5·43	14	..	..	..	..	7·46	22	4·16	15	..	..	1886
1887	4·74	..	4·06	..	4·29	..	6·28	..	8·74	..	6·25	..	7·58	17	10·43	..	10·02	..	3·36	..	13·25	..	11·31	..	90·31	186	1887
1888	3·48	..	2·96	..	5·16	..	4·38	..	1·84	..	6·70	..	3·30	..	12·63	..	10·38	..	4·18	..	7·36	..	6·35	..	68·72	..	1888
Total	46·69	..	23·89	..	21·73	..	20·78	..	47·10	..	46·85	..	32·71	..	38·32	..	47·66	..	28·06	..	60·95	..	69·35	..	..	..	Total
Mean	7·78	..	3·98	..	3·62	..	3·46	..	7·85	..	9·37	..	5·45	..	6·39	..	9·53	..	5·61	..	10·16	..	11·56	..	84·76	..	Mean
											5 years only.						5 years only.		5 years only.								

RAINFALL.—Total for Month, with Number of Rainy Days.

North Borneo.—Kudat.

Date.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		October.		Nov.		Dec.		Year.		Date.
	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1882	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13·48	19	19·45	21	..	..	1882
1883	16·82	..	7·57	..	5·83	..	3·31	..	4·36	..	3·33	..	8·47	..	4·67	..	4·22	..	8·94	..	22·56	..	30·46	..	120·54	..	1883
1884	6·72	..	0·92	..	2·94	..	1·17	..	3·38	..	8·61	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1884
1885	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1885
1886	..	..	..	..	..	..	1·11	8	3·36	6	8·08	17	6·36	11	6·49	7	7·62	16	8.50	10	12·83	19	30·24	23	..	..	1886
1887	24·63	..	16·55	..	29·75	..	3·55	..	6·39	..	7·73	..	5·68	..	5·71	..	3·05	..	11·09	..	8·05	..	14·82	..	137·00	175	1887
Limbuak-Banguey.																											
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1886	2·29	4	5·10	6	7·20	2	2·88	11	6·00	17	13·17	12	4·71	11	12·30	15	8·68	12	..	..	..	..	..	..	..	..	1886
1887	11·21	..	3·11	..	24·01	..	7·39	..	8·57	..	5·44	..	7·20	..	22·12	..	4·62	..	18·04	..	14·23	..	17·71	..	143·65	224	1887
Papar.																											
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1882	6·02	11	1·98	12	4·70	11	6·25	12	6·88	9	9·13	14	6·45	15	20·48	19	10·65	16	18·40	26	20·41	23	17·71	22	129·06	190	1882
1883	20·79	20	1·85	8	4·94	17	3·37	11	10·37	18	12·02	17	5·60	10	15·26	17	12·40	12	..	..	..	..	..	..	..	..	1883
1884	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1884
1885	0·56	6	0·28	2	..	..	0·65	1	6·68	20	8·85	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1885
1886	..	..	..	..	..	..	6·16	11	13·29	19	21·07	13	12·42	20	16·38	15	18·95	17	..	..	..	..	..	..	..	..	1886
1887	3·56	..	4·51	..	9·35	..	12·35	..	17·13	..	15·39	..	4·68	..	13·97	..	8·12	..	10·06	..	30·49	..	16·48	..	146·09	199	1887
1888	..	..	..	..	2·67	..	..	..	..	..	11·66	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1888
Mempakol.																											
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1886	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14·82	13	13·37	15	20·82	17	..	..	1886
1887	10·28	..	3·12	..	11·08	..	31·37	..	9·36	..	14·80	..	7·71	..	33·47	..	..	..	..	..	26·74	22	..	..	..	..	1887
Gaya.																											
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1887	..	..	1·17	..	8·99	..	15·23	..	15·16	..	8·60	..	6·83	..	18·18	..	5·70	..	6·98	..	31·15	..	7·08	..	..	196	1887
1888	8·56	..	..		0·92	..	3·53	..	..	..	8·61	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1888

RAINFALL AT LABUAN AND SARAWAK.

Date.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		October.		Nov.		Dec.		Year.		Date.
	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	Total.	Days.	
	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1855	4·97	..	5·20	..	3·17	..	7·04	..	3·99	..	14·80	..	13·04	..	2·43	..	6·47	..	7·22	..	8·89	..	17·97	..	95·19	..	1855
1856	4·68	..	3·54	..	10·95	..	8·89	..	9·60	..	4·30	..	15·01	..	20·42	..	7·70	..	14·21	..	17·70	..	19·25	..	136·25	..	1856
1857	13·78	..	14·10	..	9·49	..	8·53	..	13·32	..	5·73	..	13·65	..	5·59	..	6·66	..	25·63	..	6·12	..	14·31	..	136·91	..	1857
1858	4·48	..	10·58	..	13·22	..	11·14	..	16·14	..	6·88	..	10·85	..	8·26	..	10·60	..	15·11	..	7·89	..	17·18	..	132·33	..	1858
1879	16·94	..	4·52	..	10·35	..	9·77	..	6·94	..	15·04	..	23·00	..	27·96	..	7·17	..	13·78	..	10·03	..	5·65	..	151·15	..	1879
1880	20·24	..	9·91	..	1·97	..	9·19	..	15·33	..	17·74	..	7·16	..	9·75	..	14·13	..	13·50	..	10·29	..	14·70	..	143·91	..	1880
1881	7·84	..	3·01	..	0·14	..	2·98	..	14·11	..	31·07	..	6·59	..	14·88	..	14·30	..	21·57	..	18·18	..	12·93	..	147·60	..	1881
1882	10·41	..	3·34	..	18·87	..	4·19	..	9·27	..	10·41	..	4·64	..	20·02	..	7·78	..	19·74	..	20·86	..	12·58	..	142·11	..	1882
1883	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	167·70	..	1883
1884	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	118·85	..	1884
1885	0·59	..	0·36	..	0·96	..	8·45	..	11·78	..	11·59	..	13·91	..	6·60	..	20·21	..	16·37	..	23·23	..	5·95	..	120·00	..	1885
1886	4·67	..	1·04	..	0·21	..	8·02	..	42·37	..	10·43	..	10·16	..	18·09	..	11·93	..	10·78	..	14·41	..	22·55	..	154·66	..	1886
1887	7·02	..	1·76	..	10·56	..	13·90	..	12·08	..	16·05	..	3·95	..	32·94	..	12·19	..	2·68	..	17·10	..	9·43	..	139·66	..	1887
11 years	95·62	..	57·36	..	79·89	..	92·10	..	154·93	..	144·04	..	121·96	..	166·94	..	119·14	..	160·59	..	154·70	..	152·50	..	1786·32	..	11 years
Mean ..	8·69	..	5·21	..	7·26	..	8·37	..	14·08	..	13·09	..	11·09	..	15·18	..	10·83	..	14·60	..	14·06	..	13·86	..	137·41	..	Mean

KUCHING, SARAWAK, 1° 28′ N. 110° 8′ E.

	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1884	33·31	30	12·98	15	10·29	19	14·46	15	7·77	?	10·85	8	3·07	?	10·04	13	3·48	?	8·84	15	20·04	18	52·36	26	187·49	..	1884
1885	..	..	18·90	?	7·81	10	13·05	?	11·40	13	8·72	10	6·63	13	6·42	?	10·42	17	11·94	18	9·68	20	31·12	28	..	..	1885
1886	20·60	?	43·83	27	16·93	21	8·45	18	12·38	20	5·34	15	7·84	17	11·08	21	9·81	?	11·50	19	13·38	?	11·93	20	173·07	..	1886
1887	26·91	23	29·59	21	11·06	24	9·68	17	9·86	20	14·47	18	4·96	8	9·35	20	8·41	13	9·83	16	14·26	22	18·07	23	166·45	..	1887
1888	27·90	16	12·95	17	4·48	17	4·62	11	4·16	17	4·43	13	1·35	5	7·46	7	6·90	10	7·58	19	10·54	23	15·04	21	107·41	..	1888
5 years	108·72	..	118·25	..	50·57	..	50·26	..	45·57	..	43·81	..	23·85	..	44·35	..	39·02	..	49·69	..	67·90	..	128·52	..	..	..	5 years
Mean ..	27·18	..	23·65	..	10·11	..	10·05	..	9·11	..	8·76	..	4·77	..	8·87	..	7·80	..	9·94	..	13·58	..	25·70	..	..	..	Mean ..

TRUSAN, SARAWAK.

	In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		In.		
1888	15·72	13	10·97	19	15·56	18	13·57	18	15·41	23	6·21	10	4·74	11	9·78	16	12·13	20	17·31	21	16·76	25	15·18	23	153·34	217	1888

DUTCH BORNEO.—RAINFALL.

BANJERMASSING, 1850–1858. Lat. 114° 35′ E. 3° 19′ S.

Date.	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Year.		Date.
	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	Total. In.	Days.	
1850–58 ..	..	23	..	20	..	17	..	14	..	14	..	12	..	16	..	11	..	9	..	13	..	17	..	24	..	190	1850–58
BANJERMASSING, 1879–1887. Lat. 114° 35′ E. 3° 19′ S.																											
1879–87 ..	12·20	22	10·98	21	11·77	20	7·96	14	6·18	14	6·18	13	3·74	9	4·37	11	2·36	6	4·88	12	8·07	17	13·35	21	92·04	180	1879–87
PENGARON, 1879–1887. Lat. 115° 15′ E. 3° 15′ S.																											
1879–87 ..	13·74	21	9·57	19	14·49	24	8·78	17	9·18	18	7·25	16	3·66	9	4·41	9	2·44	7	5·79	11	10·40	19	14·57	22	104·28	192	1879–87
BARABEI, 1879–1887. Lat. 115° 16′ E. 2° 17′ S.																											
1879–87 ..	8·47	15	11·42	17	12·56	20	7·99	16	8·47	13	8·35	13	4·65	8	4·80	11	2·99	7	6·06	12	10·99	17	12·64	20	99·39	169	1879–87
AMOENTHAI, 1879–1887. Lat. 115° 10′ E. 2° 15′ S.																											
1879–87 ..	12·60	18	12·09	19	15·48	20	7·36	15	8·99	13	7·05	12	3·39	7	2·99	10	2·88	7	4·49	11	10·95	16	13·82	20	102·09	168	1879–87
BOENTOK, 1881–1887. Lat. 114° 30′ E. 1° 15′ S.																											
1881–87 ..	11·14	18	10·99	18	13·35	19	10·87	19	10·87	16	5·63	12	4·02	8	5·12	11	4·49	8	7·05	11	14·06	18	14·14	19	111·73	177	1881–87
PONTIANAK, 1879–1887. Lat. 109° 20′ E. 0° 1′ N.																											
1879–87 ..	12·17	18	7·44	11	9·49	14	8·74	14	9·21	14	9·80	13	4·73	8	9·06	14	8·66	11	17·44	19	16·38	20	15·95	19	129·05	175	1879–87
SINTANG, 1879–1887. Lat. 111° 32′ E. 0° 7′ N.																											
1879–87 ..	13·55	18	12·44	17	13·31	19	12·17	18	11·97	16	11·26	15	7·99	11	12·13	15	9·41	13	14·69	19	14·37	21	15·00	22	148·29	204	1879–87
SING KAWANG, 1879–87. Lat. 108° 59′ E. 0° 55′ N.																											
1879–87 ..	14·77	21	8·43	12	6·38	14	7·72	15	7·05	14	6·81	12	4·41	8	11·07	14	5·59	11	13·07	19	15·75	23	18·63	23	119·68	186	1879–87

DUTCH BORNEO.—TEMPERATURE.

BANJERMASSING.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1850–58 ..	80°·2	80°·4	80°·8	81°·3	81°·5	80°·8	79°·5	79°·9	80°·8	81°·4	80°·9	79°·9	80°·6

For Banjermassing all that I can find, in addition, are tables of the mean temperature and of the number of rainy days, 1850-58, which appeared in the Netherlands Meteorological *Jaarboek* for 1859. The temperature tables have been quoted by Dove in his *Klimatologische Beiträge*, part II. p. 98. I have inquired at Utrecht, but cannot learn that in Borneo any other observations have been made subsequently, except the rain returns which are printed by Dr. Van der Stok.

ADDENDUM, OCTOBER 22ND, 1889.

Since the Paper was written, and while it was passing through the press, the log of H.M.S. *Rambler*, Capt. Hon. F. C. P. Vereker, has been received at the Meteorological Office.

This log was found to contain observations made in or near Sandakan Bay during the month of April 1889, and it has been thought desirable to add to the paper a summary of the information thus obtained.

The observations were taken every two hours, with verified instruments:

METEOROLOGICAL OBSERVATIONS TAKEN ON BOARD H.M.S. *Rambler*, IN OR NEAR SANDAKAN BAY, NORTH BORNEO, FROM MARCH 31ST TO APRIL 30TH, 1889.

	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.
Barometer (corrected & reduced to 32° Fah. Height above Sea 8 ft.)	29·882	29·877	29·895	29·929	29·934	29·914	29·866
Dry-Bulb Thermometer	82·3	81·8	81·7	82·7	84·0	84·8	84·8
Wet-Bulb Thermometer	80·5	80·2	80·3	80·7	81·2	81·5	81·8
Sea Surface Temperature	85·3	85·2	85·2	85·4	85·7	85·9	86·0
Wind Direction:—							
No. of Observations under each point — N	0	0	0	0	0	0	0
NE	3	3	2	3	3	8	7
E	8	7	4	3	5	7	12
SE	5	4	6	6	6	7	5
S	6	7	7	7	3	2	0
SW	5	6	7	5	7	3	4
W	0	0	1	1	2	0	0
NW	0	0	1	0	0	0	0
Calm	3	3	2	5	4	3	2
Wind Force by Beaufort Scale	1·4	1·4	1·2	1·0	0·8	1·2	1·5
Cloud Amount	4·9	4·7	4·8	4·5	4·7	4·7	5·1

	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Midt.	Mean.
Barometer (corrected and reduced to 32° Fah. Height above Sea 8 ft)	29·841	29·854	29·889	29·916	29·912	29·892
Dry-Bulb Thermometer	85·0	84·1	83·7	83·4	83·1	83·5
Wet-Bulb Thermometer	81·7	81·4	81·3	81·2	81·0	81·1
Sea Surface Temperature	86·1	85·9	85·7	85·5	85·4	85·6
Wind Direction:—						
No. of Observations under each point — N	0	0	1	0	0	0·1
NE	11	11	7	6	6	5·8
E	12	14	12	12	11	8·9
SE	4	4	5	5	5	5·2
S	0	0	0	0	2	2·9
SW	2	0	1	3	3	3·8
W	0	0	1	1	0	0·5
NW	1	1	0	1	0	0·3
Calm	0	0	3	2	3	2·5
Wind Force, by Beaufort Scale	1·7	1·6	1·6	1·5	1·3	1·4
Cloud Amount	4·6	4·7	4·7	4·7	4·4	4·7

DISCUSSION.

Captain MACLEAR said he had lately been studying the meteorology of the Eastern Archipelago, and that our information was so scant about the region between latitudes 6° N and 6° S that this paper was all the more valuable. The paper showed that on the north-east coast of Borneo the rainy season occurred with the North-east Monsoon, as on the east coasts of the Philippines; but on the west coasts of the Philippines the rainy season occurred with the South-west Monsoon, and probably if we had observations for the west coast of Borneo, it would be found that there also the rainy season was with the South-west Monsoon. He had found the rule with all the large islands of the Archipelago to be that the weather side of the island had the rainy season, while the other side had the dry season.

THE THUNDERSTORMS OF JUNE 2nd, 6th, and 7th, 1889.

By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant-Secretary.

[Read June 19th, 1889.]

THE thunderstorms which prevailed over England on June 2nd, 6th, and 7th were of such a remarkable and severe character that an account, however brief, will no doubt be of some interest to the Society. Most of these storms were accompanied by hail of such tremendous size that a paper might very well be written on each storm.

On Sunday morning, June 2nd, a thunderstorm passed across England in a northerly direction from Wiltshire about 8 a.m., and reached Edinburgh at 10.44 a.m. The times of the occurrence of the first thunder at several places are given on the map (Fig. 1). From these it will be seen that the storm progressed at a nearly uniform speed over the 400 miles, the rate of travel being about 50 miles an hour. A few notices of thunderstorms in the east of Scotland during this day were published in the newspapers, but the times were not stated. If these referred to the storm under discussion, it is possible that it travelled still further north, and reached Kirkwall in the Orkneys at 8.37 p.m. If this should be the case, we have the very remarkable and interesting instance of a thunderstorm travelling from south to north in a straight path for fully 550 miles at the uniform rate of 50 miles an hour.

This storm was very similar to that which occurred on May 18th-19th 1888. (See *Quarterly Journal*, Vol. XIV. p. 296.)

Large hailstones fell at a few places, the following being the size of the largest stones:—

DROITWICH.—One weighed over 3 oz.
WOLLASTON.—Some were 1½ in. and 1 in. in diameter.
BOLTON.—2 to 3 ins. in circumference.
MELTHAM, YORKS.—About the size of marbles.

This storm was not very destructive, only four cases of damage by lightning being reported.

A severe thunderstorm prevailed in the neighbourhood of the Tweed between 11 a.m. and noon, and was accompanied by hail of very large size.

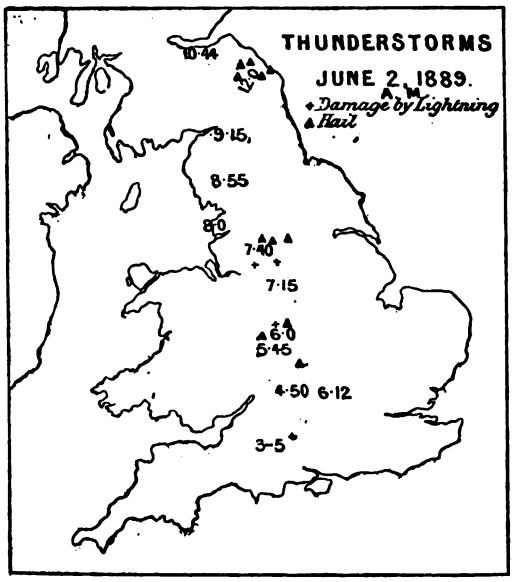

FIG. 1.

The following are the dimensions of some of the largest hailstones:—

DUNS.—3 to 5 ins. in circumference, and weighed up to 4 oz. each.
CHIRNSIDE.—Some larger than Bantam's eggs.
COLDSTREAM.—Pellets larger than marbles, some 3 to 6 ins. in circumference.
CORNHILL.—Resembled small apples. Largest measured 1⅛ in. in diameter.
PAWSTON.—1½ in. across, or 4½ to 5 ins. in circumference.
ALLANTON.—In some cases the lumps measured 5 ins. in circumference.
SWINTON.—Size of hen's eggs. One measured 5 ins. in circumference.

This storm was accompanied with intense darkness, which necessitated the suspension of the services in some of the churches.

A most violent and destructive thunderstorm occurred over the West Midland Counties, the North-west of England, and the South of Scotland between 1 and 5 p.m. The storm commenced in Worcestershire at 1 p.m., and seems to have progressed northward and reached Cumberland about 4 p.m. This was evidently followed by a second storm about an hour later, although it is somewhat difficult to separate the one from the other.

The lightning did much damage; several human beings were struck, and a large number of animals were killed. The places where these occurrences took place are each shown by a cross on the map (Fig. 2).

The storm was accompanied by a fall of hail of very large size. The following are particulars of the size of some of the stones:—

ACCRINGTON.—2 ins. in circumference.
BLACK COUNTRY.—1 in. in diameter and 4½ ins. in circumference.
BLACKLEY.—1¼ and 1½ in. long, and weighed from 1 to 1½ oz.

CHESTER.—Many weighed 2½ oz. and measured 4 to 6 ins. in circumference.
GARSTANG.—One of the ice blocks picked up measured 7 ins. in circumference, and many measured 5 ins. They for the most part consisted of round balls like

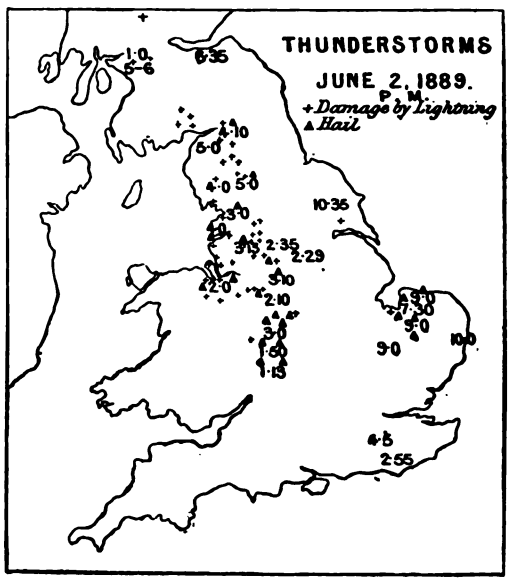

FIG. 2.

glass marbles, covered with large crystals of ice, somewhat resembling as a whole large blocks of sugar candy. The 7 ins. block, when melted, gave 0·12 in. of water in a 5 inch rain-gauge measure.
LIVERPOOL.—Ten picked up at random as being fairly large ones measured from ⅞ to 1¾ in. in greatest diameter. Many of them were of four, five or six concentric layers, which were alternately clear and snow white.
MELTHAM.—1⅜ in. longest diameter, 1⅛ in. shortest, ½ in. thick.
PENKRIDGE.—As large as walnuts.
PENRITH.—1 in. in length.
RABY.—Longest dimension was $1\frac{7}{16}$ in.
SOWERBY BRIDGE.—1¼ to 1¾ in. in diameter.
STAFFORD.—One piece of ice measured 3 ins. long, and was about an inch thick and broad.

A thunderstorm, accompanied with hail of tremendous size, prevailed over the west of Norfolk during the night of this same day (Sunday). The storm commenced about 7.30 p.m., and continued for several hours.

The following notes give particulars of the size of some of the hail-stones:—

BAGTHORPE.—Hailstones measured 4 or 5 ins. round, and weighed over an ounce.
BIRCHAM.—About 2 ins. long.
CASTLEACRE.—The stones were of enormous size, many at least 8 or 9 ins. round.
DOCKING.—Heavy blocks of ice. Some of the hailstones were 3 ins. in diameter, and weighed 3½ ozs.
LITEHAM.—One block of ice measured 2½ ins. long.
MASSINGHAM.—Hailstones 3 or 4 ins. in circumference.

SPORLE.—Very large hailstones; one picked up inside a dwelling house measured 8 ins. in circumference. Large pieces of ice of irregular shape, 2 to 3 ins. in length, also fell.

SWAFFHAM.—As large as hen's eggs. The centre of the stones consisted of a hard clear mass of ice.

WEASENHAM.—Blocks of ice and hail were of many shapes and forms, and varied from 5 to 6 ins. in circumference.

On Thursday, June 6th, thunderstorms prevailed during the afternoon and evening over the whole of the South-east of England. At many places there were two, and in some cases three, distinct storms, which followed each other after two or three hours' interval. The general tendency was for the storms to move in a northerly or north-westerly direction (Fig. 3).

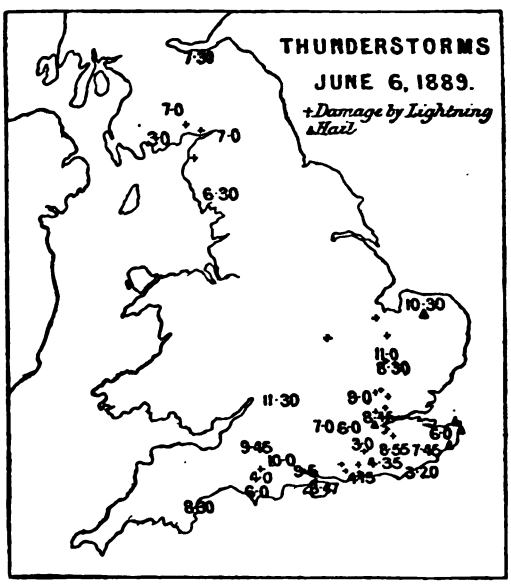

FIG. 3.

The lightning was destructive in Sussex, Hertford and Cambridge.

The storm which passed over London commenced a little before 9 p.m., and continued for nearly two hours. There were, in fact, three distinct storms, but as they occurred at the same time, they may be considered as one storm.

The storm was remarkable for the brilliant and continuous display of lightning, and was without doubt the grandest storm that has been witnessed in the Metropolis for many years. Occurring just after sunset, the conditions were very favourable for carefully watching the storm and for photographs to be taken of the lightning.

The play of the lightning was on the grandest scale; two, three, four or more flashes appearing in different parts of the sky or on the horizon at the

same time. Some idea of the frequency of the flashes may be gathered from the fact that Mr. H. S. Wallis at Highgate counted 1,244 distinct displays of lightning during the two hours ending 11.10 p.m., which gives an average of more than 10 per minute.

One of the most remarkable features of the storm was the persistent and repeating character of the lightning. Many of the flashes appeared to remain visible for a perceptible length of time, some people being able to count 6, 7, 8, and even 10 before the flash disappeared. There were numerous instances in which the lightning appeared to repeat itself three, four, or more times. It is probable that these were distinct flashes following precisely the same path. This supposition is confirmed by some of the photographs of lightning which were taken during the storm. Mr. Ninnies, of Balham, obtained two photographs, each with four distinct flashes following precisely the same path and sinuosities, and only separated from each other by a very small amount of space. These appeared at the time to Mr. Ninnies as one flash. Fortunately, the photographic views include some railway signals, and an examination of these reveals the fact that there are four distinct images of the signals. The space between the images of the signals agrees precisely with the space between the flashes of lightning. As the camera was held in the hand and not clamped to a tripod, it is clear that the camera was moved slightly during the exposure, and what appeared to the eye as one flash was in reality a succession of four flashes.

A similar repetition of flashes is shown on several other photographs, and in each case the camera was held in the hand.

A most interesting photograph was taken by Dr. Hoffert at Ealing. This was obtained while the camera was being swayed to and fro. It shows three similar parallel flashes which took place during the movement of the camera in one direction. The space between the flashes is traversed by faint bands of light parallel to the direction of motion, which appear to indicate the existence of a residual illumination of a phosphorescent character in the intervals between the successive flashes. A second series of three flashes is shown in the upper part of the photograph, as well as a dark flash; while a third series of two flashes, but with a wider interval between them, is also shown on the plate.

Some photographs showing flashes like a broad band or curtain of light were also obtained during this storm; but in each case it has been ascertained that the camera was either held in the hand or not securely fixed. These seem all to lead to the conclusion that a lightning flash is not instantaneous, but has a much longer duration than has generally been supposed to be the case.

Three or four photographs showing dark flashes were obtained during this storm, the most notable being those taken by the Rev. A. Rose, at Emanuel College, Cambridge, and by Mr. A. W. Clayden, at Tulse Hill, London. The latter gentleman has since made a number of experiments in photographing the sparks from an electric machine, which tend to show that the dark flashes were due to photographic reversal.

A large number of the flashes during this storm appeared to ascend from

the earth to the clouds. Dr. Tripe estimated that about one-fourth or one-fifth of the flashes were upward ones.

At Cambridge the storm was the severest that had occurred for 80 years.

During the early morning hours of Friday, June 7th, a very destructive thunderstorm prevailed over the western part of Norfolk, the lightning doing much damage, and killing a number of animals.

Another storm occurred about the same time (between 2 and 8 a.m.) over the east of Kent, Essex and Suffolk, during which large hail fell. Mr. Sear, at Westgate-on-Sea, says the flashes of lightning were too frequent to count their rate, the most careful attempt to do so breaking down at the high number of 181 to the minute.

Thunderstorms burst forth again over the Eastern Counties between 7 and 8 a.m., and also between 10.30 a.m. and noon, damage being caused by lightning at several places. The storm was most severe in and around Ipswich (Fig. 4).

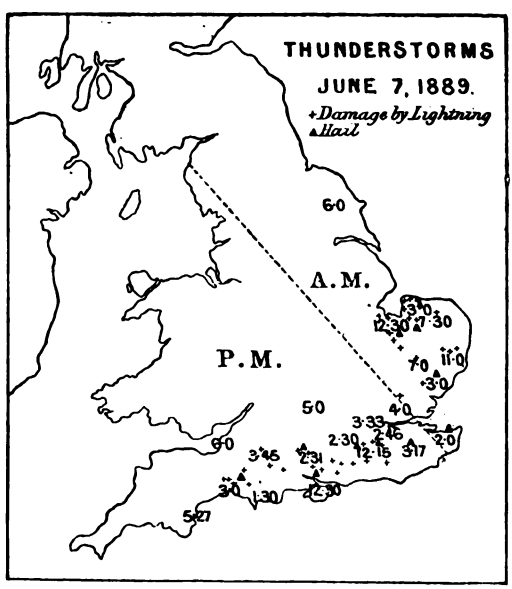

FIG. 4.

Between noon and 6 p.m. a very destructive thunderstorm, or series of thunderstorms, burst over the whole of the Southern Counties, from Kent to Dorset and Somerset. Much damage was caused by the lightning, several people being struck. The storm at Tunbridge Wells about 8 p.m. was of a most violent character, the town and neighbourhood being bombarded by a terrific hailstorm. The hailstones were very large. Mr. Young, of Barden Mill, weighed a hailstone which was half-a-pound in weight.

In the foregoing remarks, although I have not referred at all to rainfall,

it must not be supposed that no rain fell during these storms. The rain was often very heavy, and in some cases produced local flooding for a short time after its cessation.

I have given great prominence to the size of the hailstones, as I think that so much large hail falling over so many districts is without parallel. It must not be supposed that all the measurements were taken with scientific accuracy, but they prove that the hailstones were of very great size.

DISCUSSION.

THE PRESIDENT (Dr. Marcet) remarked that Mr. Wimshurst had photographed the sparks from his electric machine, while the photographic plate in his camera was revolving between 3,000 and 4,000 times per minute, and had obtained a sharp image of the spark. Mr. Wimshurst believed from these experiments that no movement of the camera during the process of photographing a flash of lightning could in any way fog or blurr the image.

Mr. SYMONS said that he remembered nothing in London like the display of lightning on June 6th since 1857. The question as to whether the movement of the camera produced the ribbon-like appearance shown in some of the photographs of lightning exhibited, was one which he felt unable to enter into, but both Mr. Wallis (who was observing the storm of June 6th at Highgate, and counted 10 while one of the flashes was visible) and himself were much impressed with the long duration of some of the flashes. Some were certainly more rapid than others; as a rule a flash of lightning goes so rapidly that there is no time for the eye to observe it closely, but in the case of the recent storm the movement of the flashes could be distinctly followed. Regarding the hailstones which fell at many places during these thunderstorms he was inclined to be rather sceptical. He knew very large hail was occasionally met with, and he remembered in the case of the great hailstorm at Richmond on August 2nd, 1879, one stone measured $4\frac{1}{2}$ ins. long by $1\frac{1}{2}$ ins. in diameter, *i.e.* about 8 cubic inches, but even this, and even if wholly of clear ice, would weigh only $4\frac{1}{2}$ ounces—a sufficiently formidable missile it is true—but records of the size of hail required close scrutiny.

Mr. ARCHIBALD said he was rather glad these severe hailstorms had occurred, as the accounts of storms experienced in India and America would perhaps be now believed. He had seen hailstones in India approaching the size of those described in the paper. In fact these recent severe storms seemed to him to be inferior specimens of a Calcutta North-wester. Such storms could be seen almost any day during March or April at Calcutta. It seemed possible that the frequency of the flashes noted during the recent thunderstorms might be due to the oscillation of the current. He thought a rotating cylinder covered with sensitive paper might be used in connection with a camera in such a way that the proper sequence of the flashes would be recorded, instead of many flashes being intermingled on one plate, as was frequently the case with the photographs of lightning hitherto obtained.

Dr. TRIPE said that the study of the typical forms of lightning illustrated in the "Report of the Thunderstorm Committee" had prepared his eyes for what was to be seen in future thunderstorms, and consequently he had been able to observe more than he had ever previously done. He had particularly noticed the duration and continuance of the flashes in the recent storms, and that the flashes which passed from cloud to cloud were mostly much more rapid than those which passed from earth to cloud and cloud to earth. About one-fourth or one-fifth of the flashes appeared to ascend. He did not remember having observed so much slow lightning before. There was one flash (an upward one) in particular which left a kind of trail behind it, appearing to have made that part of the air through which it had passed incandescent. He observed a ribbon-flash with a distinct dark line in the centre between the streams of light. This was perhaps due to two flashes rising side by side simultaneously, and the sky being visible between them appeared as the black line. He had been told that globular lightning occurred during the storm on June 6th, but he did not observe any himself. Two and a half inches of rain and hail fell within a short distance of his house, but

he only registered 0·46 in. of rain. The hail was described as being jagged and of rather large size.

Mr. CLAYDEN said he noticed a flash very similar to that described by Dr. Tripe. It appeared to leave sparks behind it very much the same as a rocket does. Regarding the ribbon lightning, he said that the images of the objects in the photograph of lightning taken by himself were sharp and well-defined, showing that the camera was not moved while the sky was luminous, and from various other considerations he was inclined to believe, rather against his will, that the ribbon-like appearance shown in the photograph really represented what was seen in the sky.

Mr. WHIPPLE said he had attributed the double images shown in the lightning photographs previously received by the Society to the fact that the cameras had been exposed behind a window. He had made experiments which had tended to confirm his supposition, having drawn chalk lines upon a blackboard and photographed them at various angles through plate-glass. The photographs obtained exhibited very similar appearances to those shown in the lightning photographs. The dark flashes, too, had appeared to him to be due to internal reflection, but on this point he had been unable to make experiments. In the present series of photographs both the dark and ribbon flashes were shown, and in the case of the ribbon flashes he felt compelled to abandon his idea of their being the effect of refraction through a window, as both Dr. Hoffert's and Mr. Shepherd's pictures, in which latter a flash was splendidly doubled, were taken without the intervention of a window between the camera and the flash. It was exceedingly difficult to reconcile these lightning photographs with Mr. Wimshurst's photographs of the electric spark, especially supposing the flash lasted so short a time as it was usually stated. It certainly seemed that lightning flashes, instead of being so rapid in their movement, were very persistent. In the storm on June 6th he distinctly saw a beaded flash, and, like Dr. Tripe, he found himself much better able to follow the course of the lightning than he had been hitherto, because his eyes had now become educated and he knew what to look for. There was no hail at Richmond during this storm; but regarding the hail which fell in the North-western Counties, he had asked Dr. Lodge, in the course of a recent conversation, to draw rough sketches indicating the size and form of the hail experienced at Liverpool; on June 2nd they proved to be very similar to those engraved in a recent No. of *Nature*.

Dr. HOFFERT said that in one case he noticed the lightning had a distinct fluttering appearance, showing that the lightning was sufficiently slow to make its movements apparent. He did not think that Mr. Wimshurst's photographs of electric sparks could be taken as an analogy, as the conditions in nature were so different. It was difficult to understand that any oscillation of the flash could have taken place, as the forms of the flashes in the photograph taken by himself were similar. He was unable to explain the dark flash, but from experiments he had made he had been led to believe that the phenomenon was not due to excess of exposure.

Dr. GREEN suggested that the dark flashes in the photographs were produced by yellow flashes, as intense yellow gave a negative effect.

Mr. LAWSON said he had had many opportunities of watching lightning at distances beyond where the thunder was audible, and where its progress could be seen more distinctly than in the immediate vicinity of the storm. On the cloud the flashes always proceeded upwards, following all the sinuosities on its surface, and, as to duration, many were visible for fully a second. When the base of the cloud was visible he had seen flashes strike downwards to the ground, and occasionally there was a second, and sometimes a third, in rapid succession, so that all these might have appeared as one in a photograph.

Mr. BALDWIN LATHAM said that he had carefully observed the thunderstorm of June 6th at Croydon, where it commenced at 8.45 p.m. His impression was that many of the flashes of lightning left a luminous trace, and the flashes were of considerable duration, some apparently ascending and others descending. Hardly any hail fell at Croydon during this storm. The account of the large hail quoted by Mr. Marriott reminded him of the account of the storm at Margate which he had received from Mr. Masu. This gentleman had one of his windows completely riddled by hailstones, which had passed through without cracking the glass just as though it had been shot through with a pistol. Another window

had been starred with the hail, but no actual holes had been made through it. The distribution of the hail at Margate seemed to have been rather curious, as a greenhouse having about 350 panes of glass had 250 broken, while another greenhouse, not 100 yards distant and about the same level, was uninjured. This reminded him of the great thunderstorm which occurred at Croydon on Sunday, June 23rd, 1878, when hailstones from ¼ inch to ⅜ inch in diameter fell at his house, which is at a level of 260 feet above the sea. In this storm, at his house, the stones came down so gently that they did no damage, while in the neighbourhood of Croydon, Beddington and Wallington, upon lower ground, great destruction of glass occurred. From the observations which he made in this storm it appeared that hailstones began to fall at a very short distance from the earth, and in all probability they had been gyrating about for a considerable time, which accounted for the peculiar rattling sounds often heard in the air before a hailstorm, and in all probability many of the large hailstones were formed by the aggregation of a number of smaller stones while gyrating in the air.

Captain MACLEAR said that on June 6th he saw several lightning flashes that were most persistent, some lasted two seconds, and one especially faded gradually. There was slight rain and mist at the time, and perhaps this was the cause of the continuance and frequency of the flashes; when the storm passed over high ground where no rain was falling the discharges were more violent. On the high ground of Deensfold Common a cottage was struck by lightning, the walls and chimney appeared as if blown out by an explosion, a chair in which a young child was sitting being lifted from the floor by the boarding being uplifted, but the child was uninjured. Regarding the dark flash, it seemed to him that where exposure had been prolonged beyond a certain point, the next flash would appear on the plate as a dark flash, the effect of reversal known to photographers as solarisation.

Mr. RANYARD said: If we assume the ribbon flashes to have a real existence, the photographs seem to show that the ribbon never curls or turns to one side, all the turns are made so that the cross lines of the ribbon remain parallel to a fixed line. It follows from this that each edge of the ribbon is a plane curve, and the ribbon always remains between two parallel planes. A ribbon flash seen from any point between these planes would appear to project into a straight ribbon. Mr. Marriott and he had wished to determine whether there was any connection between the direction of the wind and the cross lines of the ribbon, or whether the cross lines were parallel to some fixed line in space, such as the earth's magnetic axis. He had therefore tried to observe the curvature of the lightning flashes seen in different directions during the great storm, but he had not been able to recognise any direction in which they appeared to be all straight flashes, and he had not seen any ribbon flashes or dark flashes. When he came to see the photographs taken during the great storm, his faith as to the real existence of ribbon flashes was still further shaken. There were some photographs which showed three or four parallel flashes of lightning, and three or four separate images of a railway signal post lit up by the lightning, proving that the plate must have shifted between the flashes, which were absolutely alike, turn for turn. The images of the signal post were separated by distances which corresponded with the distances between the lightning flashes, and we must consequently assume that the three lightning flashes all followed the same course in the air. This is what might theoretically be expected, for the first flash would heat the air and form a path of least resistance which subsequent flashes would travel along, as water follows the turns of a pipe. A somewhat similar photograph had been taken by Dr. Hoffert, who had intentionally moved his camera from side to side, proving that recurrent flashes occupied a considerable portion of a second, and that between each flash there was a phosphorescence which left a trace on the plate very similar to the gauge-like traces with which we were already familiar in the ribbon flash photographs. It was a very significant fact that all the photographs of ribbon flashes, as far as he was aware, had been taken with cameras held in the hands, or, at all events, with cameras which were not screwed to a fixed support, but were only held against a window-sill by the hand of the operator. And he thought that we have in these photographs evidence of the nervous condition of the operator and of the magnitude of the jump or start which the flash gave rise to. Dr. Hoffert's photograph, as well as the other photographs of multiple flashes, showed that all the flashes took place in the

same direction—for all the flashes thinned out in the same direction. There was no evidence of lightning striking first backwards and then forwards, as had been suggested.

ON THE VARIATION

OF THE

TEMPERATURE OF THE AIR IN ENGLAND During the Period 1849 to 1888.

By WILLIAM ELLIS, F.R.A.S., of the Royal Observatory, Greenwich.

(Plate XIII.)

[Received April 17th—Read June 19th, 1889.]

MR. EATON, in his late discussion of Mr. Belville's observations made at Greenwich,[1] stated as one of the general results to be gathered from his investigation, "That there was no appreciable change in the mean annual temperature of the air at Greenwich in the period 1812 to 1855 inclusive." And in some remarks which I offered on the paper in the discussion following the reading thereof, I mentioned that, as regards secular increase of temperature, the observations of the numerous observers who have contributed to the Registrar-General's *Quarterly Return*, commencing in the year 1849 and extending to the present time, did not show increase of air temperature. That statement was one made generally from an inspection of the printed values, and not as the result of any systematic discussion thereof, and I had since been intending to offer to the Royal Meteorological Society such figures, derived from these records, as might be necessary for confirming it. But the results, so far from showing increase of temperature, indicate rather that we have, during late years, been passing through a generally cold period of prolonged duration.

Firstly I would mention that the meteorological results which appear in the Registrar-General's *Quarterly Return* are derived from observations made at stations originally organised by Mr. Glaisher, especially for providing the Registrar General with information on the meteorology of the country, which observations, since their commencement in the year 1849, have been throughout also discussed by Mr. Glaisher on the same general plan. This is the principal condition necessary in an inquiry of the kind

[1] "The Mean Temperature of the Air at Greenwich from September 1811 to June 1856 inclusive." *Quarterly Journal of the Royal Meteorological Society*, Vol. XIV. p. 15.

mentioned, for whatever opinion may be held in regard to the methods of reduction employed, so long as they are similar throughout, the results are in themselves comparative, which is all that is needed. Mr. Glaisher has, from the monthly values of meteorological elements, formed quarterly values, and has further grouped the stations according to latitude; that is to say, places situated between latitudes 51° and 52° are used to give one set of mean values, the places between latitudes 52° and 53° giving another set of values, and so on. I first extracted the quarterly means of air temperature thus found, for the three principal groups, and then, from the quarterly values for years, formed quarterly values for each five years, from 1849 to 1888. These are contained in Table I., it being understood that the first quarter includes the months of January, February, and March, and so on. It should be mentioned that there has been considerable change as regards individual stations during the period dealt with, some having been given up and others commenced, but it is presumed that by the grouping of the stations according to latitude, the results are rendered generally comparative throughout, a presumption which appears to be fairly warranted by the accordance of the results obtained.

I thought it desirable to include also values for Greenwich, using the eye observation series of results, the photographic values being not yet available throughout. The values of air temperature in the eye observation series here employed are deduced from observations made usually four times daily, combined with the daily mean of the maximum and minimum temperatures, the former from 1849 to 1877 being corrected for diurnal inequality by means of corrections given by Mr. Glaisher in his paper in the *Philosophical Transactions* for 1848,[1] and the latter having the correction required by the maximum and minimum mean, as given in the same paper, duly applied. But these corrections having been determined from the observations of a small number of years, on the completion of the twenty years' photographic reductions other corrections were determined from the results thus made available,[2] which new corrections have been used in the reduction of the eye observation series since the year 1878. And in order to obtain one uniform series I have since corrected the results for the previous years, 1849 to 1877, for the difference found between the two sets of corrections. The quarterly means and the yearly means for Greenwich so found, for the same five-yearly periods as before, are given in Table II.

It should be mentioned that the values given have in no case been reduced to sea-level. To take this into account would require that the numbers should be increased by a quantity not varying in any case very much from 0°·5, which would not affect the general conclusions of this paper, since they depend throughout on the comparison of values, and not on absolute values.

[1] "On the Corrections to be applied to the Monthly Means of Meteorological Observations taken at any hour, to convert them into Mean Monthly Values."

[2] *Reduction of Twenty years' photographic records of the Barometer and Dry-bulb and Wet-bulb Thermometers, &c. made at the Royal Observatory, Greenwich.*

Letter from the author—
Mr. Glaisher's figures I have taken without correction
They are reduced with his factors.—I to have corrected
the Greenwich values.——

TABLE I.—MEAN TEMPERATURE OF THE AIR IN ENGLAND DEDUCED FROM THE RESULTS CONTAINED IN THE QUARTERLY RETURNS OF THE REGISTRAR-GENERAL.

Five-Yearly Periods.	Quarters.				Yearly Mean.
	First.	Second.	Third.	Fourth.	
For Stations situated between Latitudes 51° and 52° North.					
	°	°	°	°	°
1849 to 1853....	39·74	51·86	59·32	44·00	48·73
1854 ,, 1858....	38·40	52·38	60·56	44·78	49·03
1859 ,, 1863....	41·44	52·64	58·96	45·24	49·57
1864 ,, 1868...	39·58	54·02	59·98	44·88	49·62
1869 ,, 1873....	41·10	52·36	60·22	43·50	49·29
1874 ,, 1878 ..	41·46	52·36	60·18	44·06	49·52
1879 ,, 1883 ..	39·08	51·42	58·58	43·48	48·14
1884 ,, 1888....	39·18	51·32	59·20	43·44	48·28
Range	3·06	2·70	1·98	1·80	1·48
Mean	40·00	52·30	59·62	44·17	49·02
For Stations situated between Latitudes 52° and 53° North.					
	°	°	°	°	°
1849 to 1853 ..	39·36	50·94	58·42	43·64	48·09
1854 ,, 1858....	38·14	51·46	59·66	44·12	48·35
1859 ,, 1863...	41·00	51·44	58·14	44·10	48·67
1864 ,, 1868....	38·90	53·76	59·80	44·62	49·27
1869 ,, 1873....	40·26	51·46	59·72	43·06	48·63
1874 ,, 1878....	40·54	51·88	59·44	43·22	48·77
1879 ,, 1883...	38·32	50·14	57·70	42·48	47·16
1884 ,, 1888....	38·12	49·58	57·96	42·40	47·01
Range	2·88	4·18	2·10	2·22	2·26
Mean	39·33	51·33	58·86	43·45	48·24
For Stations situated between Latitudes 53° and 54° North.					
	°	°	°	°	°
1849 to 1853 ...	39·12	50·36	56·88	42·88	47·31
1854 ,, 1858....	38·26	50·60	58·76	43·98	47·90
1859 ,, 1863....	40·26	50·42	56·44	43·06	47·55
1864 ,, 1868....	38·28	52·30	57·78	43·86	48·05
1869 ,, 1873....	39·72	50·38	58·14	42·64	47·72
1874 ,, 1878....	40·08	50·52	57·82	42·72	47·79
1879 ,, 1883....	38·68	49·34	56·52	42·76	46·82
1884 ,, 1888...	38·66	49·06	56·72	43·04	46·87
Range	2·00	3·24	2·32	1·34	1·23
Mean	39·13	50·37	57·38	43·12	47·50

Having formed the five-yearly normal values now given, it became evident that they could not be used for the desired object, on account of the large accidental variations which occur, and which it will be seen are generally similar in each division of the table. To better show these variations to the

TABLE II.—MEAN TEMPERATURE OF THE AIR DEDUCED FROM THE EYE OBSERVATIONS MADE AT THE ROYAL OBSERVATORY, GREENWICH. LATITUDE 51° 29′ NORTH.

Five-Yearly Periods.	Quarters.				Yearly Mean.
	First.	Second.	Third.	Fourth.	
	°	°	°	°	°
1849 to 1853....	40·56	52·62	60·32	44·80	49·57
1854 „ 1858....	38·62	53·16	61·30	44·72	49·45
1859 „ 1863....	41·32	53·22	59·80	44·90	49·81
1864 „ 1868....	39·36	55·08	61·30	44·98	50·18
1869 „ 1873....	40·70	53·26	61·38	43·48	49·71
1874 „ 1878....	41·06	53·52	60·88	44·02	49·87
1879 „ 1883....	39·38	52·18	59·42	43·64	48·66
1884 „ 1888....	38·90	52·12	60·32	43·48	48·70
Range	2·70	2·96	1·96	1·50	1·52
Mean	39·99	53·15	60·59	44·25	49·49

eye, there is given in Table III. the excess of the mean temperature in each five-yearly period above the average of the whole period, grouping together the results for the same quarter in the different series.

The numbers in the column "Mean" of Table III. have been further exhibited in curves for each quarter and for the year (see Plate XII.). It would have been more interesting to give the curve for each separate series, in order to show the great similarity that exists, but there would have been a certain interlacing confusion, besides which one curve in each case sufficiently represents the others. In considering the table generally, the first thing that attracts attention is the preponderance of high temperature in the middle years of the series, and the persistent low temperature in the terminating years. The last two groups in each division of the table show that the temperature is below the average on the mean of each five years 1879-1883 and 1884-1888 in every quarter of both groups. That in two consecutive groups the average temperature of each quarter of the year should be thus extreme in the same direction seems somewhat remarkable. In no other single group is there such extreme deviation in one direction in every quarter of the year. Such inequality entirely frustrates employment of the numbers for discussion of the question of secular change of temperature, really the object which I had in view when turning my attention to these results, and for which reason, in order best to carry out that object, I formed the five-yearly means now given. Forty years is, of course, a short period for any such purpose, but it was thought that, the observations being spread over nearly the whole of England, accidental inequalities would not be so marked as when considering the observations of a single place, whereas it is now evident that the inequalities are general over the whole extent of country dealt with. The manner in which the independent results for different latitudes support each other, in throughout showing inequality of like character, affords striking proof of the reality of the results obtained. Had

TABLE III.—EXCESS OF THE MEAN TEMPERATURE OF THE AIR IN ENGLAND IN EACH FIVE-YEARLY PERIOD ABOVE THE MEAN TEMPERATURE OF THE WHOLE PERIOD, IN THE DIFFERENT QUARTERS OF THE YEAR.

Five-Yearly Periods.	Between Latitudes				For Royal Observatory, Greenwich.
	51° & 52°	52° & 53°	53° & 54°	Mean.	
First Quarter.					
1849 to 1853 ..	−0°26	+0°03	−0°01	−0°08	+0°57
1854 ,, 1858 ..	−1°60	−1°19	−0°87	−1°22	−1°37
1859 ,, 1863....	+1°41	+1°67	+1°13	+1°41	+1°33
1864 ,, 1868....	−0°42	−0°43	−0°85	−0°57	−0°63
1869 ,, 1873....	+1°10	+0°93	+0°59	+0°87	+0°71
1874 ,, 1878....	+1°46	+1°21	+0°95	+1°21	+1°07
1879 ,, 1883....	−0°92	−1°01	−0°45	−0°79	−0°61
1884 ,, 1888....	−0°82	−1°21	−0°47	−0°83	−1°09
Mean Temp.	40°00	39°33	39°13	39°49	39°99
Second Quarter.					
1849 to 1853....	−0°44	−0°39	−0°01	−0°28	−0°53
1854 ,, 1858....	+0°08	+0°13	+0°23	+0°15	+0°01
1859 ,, 1863....	+0°34	+0°11	+0°05	+0°17	+0°07
1864 ,, 1868 ...	+1°72	+2°43	+1°93	+2°03	+1°93
1869 ,, 1873....	+0°06	+0°13	+0°01	+0°07	+0°11
1874 ,, 1878....	+0°06	+0°55	+0°15	+0°25	+0°37
1879 ,, 1883....	−0°88	−1°19	−1°03	−1°03	−0°97
1884 ,, 1888....	−0°98	−1°75	−1°31	−1°35	−1°03
Mean Temp.	52°30	51°33	50°37	51°33	53°15
Third Quarter.					
1849 to 1853....	−0°30	−0°44	−0°50	−0°41	−0°27
1854 ,, 1858....	+0°94	+0°80	+1°38	+1°04	+0°71
1859 ,, 1863....	−0°66	−0°72	−0°94	−0°77	−0°79
1864 ,, 1868....	+0°36	+0°94	+0°40	+0°57	+0°71
1869 ,, 1873....	+0°60	+0°86	+0°76	+0°74	+0°79
1874 ,, 1878 ...	+0°56	+0°58	+0°44	+0°53	+0°29
1879 ,, 1883....	−1°04	−1°16	−0°86	−1°02	−1°17
1884 ,, 1888....	−0°42	−0°90	−0°66	−0°66	−0°27
Mean Temp.	59°62	58°86	57°38	58°62	60°59
Fourth Quarter.					
1849 to 1853....	−0°17	+0°19	−0°24	−0°07	+0°55
1854 ,, 1858....	+0°61	+0°67	+0°86	+0°71	+0°47
1859 ,, 1863....	+1°07	+0°65	−0°06	+0°55	+0°65
1864 ,, 1868....	+0°71	+1°17	+0°74	+0°87	+0°73
1869 ,, 1873....	−0°67	−0°39	−0°48	−0°51	−0°77
1874 ,, 1878....	−0°11	−0°23	−0°40	−0°25	−0°23
1879 ,, 1883....	−0°69	−0°97	−0°36	−0°67	−0°61
1884 ,, 1888....	−0°73	−1°05	−0°08	−0°62	−0°77
Mean Temp.	44°17	43°45	43°12	43°58	44°25
The Year.					
1849 to 1853....	−0°29	−0°15	−0°19	−0°21	+0°08
1854 ,, 1858....	+0°01	+0°11	+0°40	+0°17	−0°04
1859 ,, 1863....	+0°55	+0°43	+0°05	+0°34	+0°32
1864 ,, 1868....	+0°60	+1°03	+0°55	+0°73	+0°69
1869 ,, 1873....	+0°27	+0°39	+0°22	+0°29	+0°22
1874 ,, 1878....	+0°50	+0°53	+0°29	+0°44	+0°38
1879 ,, 1883....	−0°88	−1°08	−0°68	−0°88	−0°83
1884 ,, 1888....	−0°74	−1°23	−0°63	−0°87	−0°79
Mean Temp.	49°02	48°24	47°50	48°25	49°49

the last two sets of means in each division of Table III. been wanting, it might have been supposed that there was some evidence of increase of temperature, but the means 1879 to 1883 and 1884 to 1888 are persistently low in each quarter without exception. We see further the impossibility of determining mean values of temperature in this part of the world from observations extending over so small a period as ten years. For, forming the yearly mean for such periods from the numbers given in Tables I. and II., we have the following results :—

Period.	Between Latitudes 51° & 52°.	52° & 53°.	53° & 54°.	Royal Observatory Greenwich.
	°	°	°	°
1849 to 1858	48·88	48·22	47·60	49·51
1859 to 1868	49·59	48·97	47·80	49·99
1869 to 1878	49·41	48·70	47·75	49·79
1879 to 1888	48·21	47·09	46·85	48·68
Extreme range	1·38	1·88	0·95	1·81

These differences of annual means are, I think, very striking and instructive. The greater range between latitudes 52° and 53° may be due to the more inland position of stations in this group. But monthly means afford instances of yet greater inequalities. Thus, in Mr. Eaton's table of Belville temperatures, Table V. of the paper to which reference has already been made, the mean temperature of the month of December for the period 1811 to 1819 (nine years) is 37°·3, and for the period 1820 to 1828 (also nine years) is 41°·8, a difference of 4°·5. Again the mean temperature of the month of October for the period 1855 to 1866 (twelve years) for Greenwich, as found from the eye observation series here employed, is 52°·0, and for the period 1867 to 1881 (fifteen years) is 49°·2, a difference of 2°·8. Evidently, therefore, to obtain reliable mean values in England, observations through a long series of years are required. Whilst for investigation of the existence of any appreciable secular variation of temperature in England, for which I at first proposed to employ these results, in the belief that observations made at many stations reduced throughout on the same plan might give some information thereon, it is clear that the variations in individual years and periods, throughout the area over which the observations extend, are altogether too great for such a purpose.

I have thought that it might be interesting to add the individual mean yearly temperature for each of the three series, and also for Greenwich. These are given in Table IV.

We see from this table the preponderance of cold in individual years in the concluding years of the series. The extraordinarily low temperature of the year 1879 has necessarily considerable influence in lowering the temperature of the 1879-1888 period, but the 1884-1888 period is equally cold, although containing no such special year. The variations in the yearly

TABLE IV.—MEAN YEARLY TEMPERATURE OF THE AIR IN ENGLAND, 1849 TO 1888.

Year.	Between Latitudes					Royal Observatory, Greenwich.
	51° & 52°.	52° & 53°.	53° & 54°.	Mean.	Excess of Mean above General Mean.	
	°	°	°	°	°	°
1849	49·5	48·1	47·3	48·3	0·0	50·2
1850	48·3	47·8	47·1	47·7	−0·6	49·5
1851	48·9	48·3	47·4	48·2	−0·1	49·4
1852	49·7	49·4	48·6	49·2	+0·9	50·8
1853	47·2	46·9	46·1	46·7	−1·6	48·0
1854	48·9	48·4	48·3	48·5	+0·2	49·4
1855	46·8	46·1	45·8	46·2	−2·1	47·3
1856	49·4	48·3	47·7	48·5	+0·2	49·4
1857	50·7	50·0	49·7	50·1	+1·8	51·5
1858	49·4	48·9	48·1	48·8	+0·5	49·7
1859	50·8	49·3	48·4	49·5	+1·2	51·2
1860	47·7	46·3	45·1	46·4	−1·9	47·4
1861	49·3	48·8	47·7	48·6	+0·3	49·8
1862	49·6	49·2	47·6	48·8	+0·5	49·9
1863	50·4	49·8	48·9	49·7	+1·4	50·7
1864	48·7	48·2	46·8	47·9	−0·4	48·9
1865	50·0	49·5	48·7	49·4	+1·1	50·7
1866	49·7	49·1	47·9	48·9	+0·6	50·2
1867	48·4	48·5	47·2	48·0	−0·3	49·0
1868	51·3	51·1	49·6	50·7	+2·4	52·0
1869	49·8	48·9	48·0	48·9	+0·6	49·9
1870	48·7	48·2	47·4	48·1	−0·2	49·1
1871	48·8	48·0	46·9	47·9	−0·4	49·1
1872	50·4	49·8	48·6	49·6	+1·3	51·1
1873	48·8	48·3	47·6	48·2	−0·1	49·3
1874	49·2	48·8	47·6	48·5	+0·2	49·8
1875	49·4	48·8	47·6	48·6	+0·3	49·7
1876	50·0	49·3	48·3	49·2	+0·9	50·4
1877	49·6	48·6	47·6	48·6	+0·3	49·8
1878	49·4	48·3	47·9	48·5	+0·2	49·6
1879	46·0	45·0	44·6	45·2	−3·1	46·2
1880	49·0	48·0	47·5	48·2	−0·1	49·4
1881	48·2	46·9	46·5	47·2	−1·1	48·7
1882	49·3	48·4	48·1	48·6	+0·3	49·6
1883	48·2	47·5	47·5	47·7	−0·6	49·3
1884	50·1	48·8	48·7	49·2	+0·9	50·7
1885	48·3	47·0	46·2	47·2	−1·1	48·6
1886	48·4	46·9	46·5	47·3	−1·0	48·7
1887	47·3	46·2	46·7	46·7	−1·6	47·8
1888	47·3	46·1	46·3	46·6	−1·7	47·7
Mean	49·0	48·2	46·5	48·3	..	49·5

mean value, and the low temperatures of later years, may be conveniently seen in the curve on Plate XII., which represents the numbers in the column "Mean" of Table IV. It is evident that in England, at any rate, we have, since the year 1879, been passing through a generally cold period, one contrasting in a marked degree with that for 1861 to 1878, which was in general continuously warm. Such sustained heat and cold, such temporary

climatic change, if we may so call it, must, one would suppose, influence in a considerable degree, not only public health, but also the conditions of agriculture. The inequalities described may have been before pointed out, but if so, the circumstances have not come to my knowledge in the same definite shape. It would be interesting to know what has happened, during the forty years here dealt with, in adjacent countries, and also in other parts of the world.

ATLANTIC WEATHER AND RAPID STEAMSHIP NAVIGATION.

By CHARLES HARDING, F.R.Met.Soc.

[Received June 19th—Read June 19th, 1889.]

The recent exceptionally fast passages between England and America made by the Inman and International steamship *City of Paris* mark an epoch in the history of rapid ocean travelling and suggest the desirability of considering whether such voyages offer advantages for weather prediction beyond those which have existed for some time past, and which experience has shown, that, in the present state of our knowledge, could not hitherto be reckoned on for practical purposes.

The owners of the *City of Paris* have very kindly supplied me with abstracts of the westward—and eastward—bound passages made in May, and although the vessel experienced generally very fine weather, it can be seen with what rapidity she passed through the different weather systems on the outward passage.

The steamship *Circassia*, keeping a log for the Meteorological Office, was also making a passage across the Atlantic at about the same time, but arriving in New York some 40 hours earlier. The changes experienced by the one vessel seem distinctly traceable to the other. A disturbance met with by the *Circassia* on May 1st was experienced by the *City of Paris* further to the eastward on the 8rd, and another disturbance met with by the *Circassia* on the 8rd was passed through by the *City of Paris* between the 5th and 6th. During the outward passage the barometer on board the *Circassia* ranged from 29·45 ins. to 30·12 ins.

The same two vessels also made the homeward passage at about the same time, and the meteorological log kept on board the *Circassia* shows an interesting case of a slow travelling disturbance, a fact which an incoming steamer might well have made known on her arrival in England. On May 17th and

18th, in about 50° N and between 40° and 25° W, the *Circassia* had a falling barometer with a Northerly wind, the barometer registering as low as 29·5 ins.; and after this a rising barometer was experienced, on May 19th and 20th, with a Southerly wind. In this case the vessel was doubtless outstripping the depression, which, like her, was travelling eastwards. The barometer during the homeward passage ranged from 29·52 ins. to 30·24 ins. The *Circassia* passed part of a vessel's deck in about 42° N, 63° W, on May 13th, also an iceberg in 47° N, 48° W, on May 16th, and she experienced a good deal of fog as far east as 40° W. To further show the dangers which existed about this time, it is seen from a report in the *Times* of May 28th that the Cunard steamship *Servia*, bound eastward, passed a derelict schooner, the *David W. Hunt*, in 44° 58′ N, 41° 41′ W, on May 23rd.

The Inman steamship *City of Paris* made the outward passage from Roche's Point to Sandy Hook in 5 days 23 hours 7 mins., the rate throughout the passage averaging 20 miles an hour, whilst the quickest run was 511 miles in the 24 hours. The homeward or eastward bound passage was made in 6 days 29 mins., which also gives an average rate of 20 miles an hour throughout the passage. Thus it will be seen that the speed now attained by our fast Atlantic liners is in excess of the average speed with which a storm-system or area of barometrical disturbance travels in its eastward course over the Atlantic.

Professor Loomis, in his *Contributions to Meteorology*, Revised Edition, says: "I have determined the average velocity of storm-centres over the Atlantic Ocean by a comparison of the monthly charts of storm tracks, published with the *International Bulletin*, for a period of four years from 1879 to 1882. The following Table shows in miles per hour the average rate of progress for each month in the year:

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
17·4	19·5	19·7	19·4	16·6	17·5	15·8	16·3	17·2	18·7	20·0	18·3

The average velocity for the entire year is 18 miles per hour." The average velocity over the United States is 28·4 miles per hour, whilst over Europe it is only 16·7 miles per hour. Professor Loomis says, "There must be a powerful cause which accelerates the movement of storm areas in the United States, and which does not operate in Southern Asia or in the West Indies, at least in an equal degree. This cause, or one of these causes, is probably the precipitation in the form of rain or snow which usually takes place on the east side of a storm area, greatly in excess of that on the west side, by which means the progress of the storm-centre is greatly accelerated."

From an investigation in the *Nautical Magazine*, Vol. L. pp. 348-361, giving the tracks of the storm-centres in the North Atlantic in 1879, based upon the United States *Monthly Weather Review*, it appears that during that year there were 59 storm-systems which left the American waters, and of these 37 crossed the Atlantic and were experienced on the European coasts, and in 30 cases the force of the wind amounted to a gale. The average speed of all the storms which crossed the Atlantic during the year was 18 miles an hour.

An instance or two of actual weather experienced may help the reader to form an opinion as to the value of the prompt receipt of observations over the Atlantic.

In March 1887 the steamship *Celtic* was steaming quickly to the eastward, and experienced a Northerly wind for about 8 days with a rapidly falling barometer, the mercury changing from 30·6 ins. to 29·0 ins. The wind attained the force of a strong gale, and was blowing with gale force for more than 24 hours. In this case the vessel was evidently overtaking a storm in its passage to the eastward. The Daily *International Chart*, published by the United States Signal Service, shows that this depression moved very slowly across the Atlantic; it only advanced 5° to the eastward, in latitude slightly to the north of 40°, between the noons of the 7th and 8th. A large area of high barometric pressure was situated to the south of Iceland, which blocked the passage for the usual path of the storm area to the north-eastward, and during the whole of the early part of the month we in England were enjoying dry and quiet weather. The disturbance apparently at length passed over Spain on the 14th.

The steamship *Ethiopia*, on December 4th and 5th, 1888, steamed from 21° W to the north of Ireland with a moderate gale from southward, the barometer rising quickly all the time, the change of reading being from 29·05 ins. to 29·95 ins., the rate of rise being more rapid as the vessel approached the land. The explanation again is that the vessel was overtaking the disturbance. The rain area in this case seemed to be limited greatly to near the central area of the storm. The disposition of pressure at this time over England, as well as to the westward, was favourable for the northerly track of storm-centres approaching our shores from off the Atlantic.

It would often happen that an incoming storm would travel at a very much higher rate than a homeward bound vessel; a case in point is well shown in a Paper I communicated to the Society on "The Storm which crossed the British Islands between September 1st and 3rd, 1883, and its Track over the North Atlantic" (*Quarterly Journal*, Vol. X. p. 7). This disturbance crossed the Atlantic at the high rate of 40 miles an hour.

The object of this Paper is not to attempt to show that storms in our Islands could be forecast by telegrams from America indicating the disturbances met with by westward bound vessels, although I have long held the opinion that with the whole fleet of Trans-Atlantic steamships co-operating in this endeavour, the system would often be highly valuable. The information obtained from westward bound vessels might be supplemented by returns promptly forwarded by eastward bound vessels, and it would be better still if such returns could be handed to some responsible person, say at Queenstown, who could concisely summarise the essence of the information before posting the returns. We could, by the receipt of information both from outward and homeward bound vessels, be in possession of data sufficiently exact to form approximate weather charts of the whole section of the Atlantic on the route followed by steamships between America and Europe. A fairly complete knowledge of the conditions prevailing over the

whole belt of the ocean might be obtained by about 3 days after date, and even in one or two days after date the conditions over this part of the Atlantic might be fairly well known.

By the extension of the *Daily Weather Report* information over a larger area of Europe, we now get a more complete account of the weather to the eastward of the British Isles, and this is doubtless of great value. It is, however, beyond dispute that by far the larger part of our weather changes come in from the Atlantic, travelling roughly in a course from West to East, or more precisely from West-south-west to East-north-east, and this simple fact points clearly to the direction in which we must look for real advance in our weather knowledge.

The feature to which I wish to attach the greatest importance is that, by carrying out the suggestion indicated above, we should have a fairly good approximate idea of the distribution of pressure over the Atlantic, and could trace the changes which are taking place from day to day.

The average conditions of barometer, air and sea temperature, wind and weather, are now well known over the whole ocean, and much advance has been made of late years in our knowledge of the different weather types which accompany certain conditions. These facts greatly enhance the value of a few isolated observations scattered over the Atlantic, since from these we can judge whether the conditions are normal or abnormal, and with improved weather types fresh advantages would undoubtedly accrue.

I will not here enter into the details which might be adopted with the view of improving our knowledge of the existing conditions; a study of the *Atlantic Synchronous Charts* of the Meteorological Office will in a great measure suggest these.

In conclusion I have, however, to thank the Meteorological Council for permission to use the materials from the Office Logs.

RAINFALL IN CHINA IN 1888.

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Station.	Lat. N.		Long. E. Greenwich.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	′	°	′	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Houki	38	4	120	39	..	..	0·48	0·42	..	1·11	8·46	7·91	0·64	1·08	2·14	..	22·24
Chifu	37	34	121	32	0·70	0·50	0·58	1·25	0·55	2·21	12·50	7·57	0·54	0·25	3·22	..	29·87
Chemulpho, Korea	37	29	126	37	1·06	0·71	2·06	2·02	1·18	1·83	9·16	0·83	1·30	1·16	1·11	0·68	23·10
Shanotung Promontory	37	24	122	42	0·40	..	0·46	2·92	0·30	1·76	11·95	1·46	0·76	..	1·30	0·80	22·11
Fusan, Korea	35	5	129	6	1·06	0·24	2·52	3·88	1·82	3·92	2·72	1·12	2·96	5·34	8·20	1·46	35·24
Chinkiang	32	12	119	30	2·53	1·61	3·68	4·93	0·69	2·02	5·45	0·42	1·01	0·31	3·68	..	26·33
Wusung	31	25	121	27	2·38	1·82	4·00	1·06	3·64	3·65	5·41	5·50	4·60	4·00	2·11	0·66	38·83
Sha-wei-shan	31	25	122	15	2·12	2·54	3·22	1·79	0·73	3·87	4·26	1·95	6·61	2·78	1·39	1·39	32·65
Wuhu	31	22	118	22	2·84	4·94	3·73	5·60	1·65	0·74	6·97	1·59	1·66	1·95	1·99	0·46	34·12
Hankau	30	33	114	20	3·54	1.59	5·61	7·54	3·58	0·90	5·40	9·11	1·45	2·47	0·78	0·23	42·20
Ichang	30	12	111	19	2·52	1·68	3·61	5·10	4·40	2·02	7·11	6·70	7·56	2·64	0·52	0·74	44·60
Steep Island	30	12	122	36	2·91	3·39	3·69	4·41	2·42	8·87	3·50	1·60	8·96	2·27	5·39	2·86	50·27
Ningpo	29	58	121	44	7·11	4·92	6·59	5·16	3·68	10·40	4·61	5·12	7·12	6·37	3·75	3·59	68·42
Kiukiang	29	43	116	7	4·52	5·69	5·64	6·35	6·98	8·01	6·38	12·75	1·07	4·33	1·77	0·82	64·31
Wenchau	28	0	120	35	2·32	4·62	4·88	7·84	9·65	19·97	4·00	8·29	7·50	3·25	3·68	4·12	80·12
Fuchau	26	8	119	38	0·55	3·62	5·00	6·63	6·12	8·85	1·20	20·11	2·99	3·74	1·54	3·59	63·94
Middle Dog	25	58	120	2	0·55	4·12	5·05	11·10	2·31	10·50	1·62	10·31	0·82	5·16	1·90	4·36	57·80
Turnabout	25	26	119	59	0·64	3·85	3·83	6·88	2·58	8·87	0·19	8·16	1·40	5·04	0·68	4·17	46·29
Tamsui, Formosa	25	10	121	25	3·15	14·06	3·66	5·79	4·07	17·49	0·46	6·49	8·54	2·79	2·70	6·78	75·98
Ke-lung, Formosa	25	8	121	45	15·28	24·90	11·17	4·85	8·04	14·51	1·72	11·42	13·18	6·12	11·79	23·41	146·39
Ockseu	24	59	119	28	0·21	3·13	2·04	8·45	4·23	4·97	..	11·34	5·12	3·09	0·14	2·17	44·89
Amoy	24	27	118	4	0·78	4·29	5·27	16·40	9·66	3·40	2·17	13·76	0·91	4·01	..	3·20	63·85
Chapel Island	24	10	118	13	0·29	3·69	3·17	7·86	2·69	6·15	0·39	3·29	2·45	1·62	0·13	2·11	33·84
Fisher Island	23	33	119	28	..	3·37	0·86	6·23	5·71	5·98	0·14	16·32	2·86	2·08	0·86	1·52	45·93
Swatau	23	20	116	43	0·22	4·21	2·96	14·80	8·07	14·89	3·46	8·40	0·38	5·55	0·32	2·68	65·94
Lamocks	23	15	117	18	0·31	4·10	1·92	9·67	5·57	6·89	2·42	4·19	1·68	1·71	1·15	1·03	40·64
Canton	23	7	113	17	0·85	2·95	14·75	12·25	15·15	14·85	15·15	8·85	4·77	4·13	1·07	2·37	97·14
Anping, Formosa	22	59	120	13	..	1·75	1·38	2·83	6·88	14·33	2·04	31·49	0·12	1·35	1·15	4·08	67·40
Breaker Point	22	56	116	28	0·15	4·62	1·88	15·91	13·22	21·33	3·69	6·75	2·24	2·63	0·84	2·00	75·26
Takau, Formosa	22	36	120	16	..	1·20	1·10	2·61	9·54	14·02	1·67	30·43	4·30	0·14	1·91	3·64	70·56
Hongkong	22	18	114	10	0·18	3·97	10·43	6·95	19·53	23·86	10·55	13·32	6.41	4·52	0·77	4·09	104·58
South Cape, Formosa	21	55	120	51	1·32	4·00	1·42	0·71	3·87	9·12	11·98	12·46	9·47	0·73	10·95	2·17	68·20
Pakhoi	21	29	109	6	1·15	2·28	6·88	6·38	6·01	23·28	13·96	20·92	5·09	1·26	1·89	5·93	95·03
Kiungchow, Hainan	20	3	110	20	1·20	1·10	3·60	6·40	5·35	3·70	7·10	3·60	8·40	10·04	1·06	4·13	55·68

METEOROLOGICAL OBSERVATIONS MADE AT ICHANG, CHINA, and at SOUTH CAPE, FORMOSA, in 1888.

By WILLIAM DOBERCK, Ph.D., F.R.Met.Soc., Government Astronomer, Hongkong.

[Received May 13th.—Read June 19th, 1889.]

The meteorological stations at Ichang, far inland in China, and at South Cape, washed by the Pacific Ocean, supply a useful link between Hongkong, Zi-Ka-Wei and Japan. Ichang is also nearer the stations inland in Siberia, of whose peculiarities its climate partakes to a slight extent. It is, therefore, believed that the reduction and publication of results of observations made during a whole year is not a superfluous work.

The observations have been made in accordance with the *Instructions for making Meteorological Observations in China*, issued by the author in 1883, with instruments verified at the Hongkong Observatory. Neither station has been inspected since that year.

The atmospheric pressure at South Cape has been reduced to mean sea-level, but not so at Ichang, the altitude of the latter station being known only from barometric comparisons. The corrections—to observations made in slightly modified and enlarged Stevenson screens—required to reduce them to true air temperature, according to *Observations and Researches made at the Hongkong Observatory in the year 1886* (Appendix A), have not been applied, as the results for the inland station plainly indicate them to be insufficient, because too small for that station. The author believes that on some hot days the thermometers in Ichang indicate temperatures 6° above the air temperature. The corrections might, however, with advantage be applied at South Cape, as the instruments there are well exposed.

In this connection the following remark from the 6th par. of my *Annual Report for 1886*, published on the 31st August 1887, may be considered:—

"The results obtained by comparison of thermometers exposed in Stevenson's screen with the true air and damp bulb temperatures, showed the temperature in the screen to be generally a little too low during the night, a fact that would scarcely be noticeable in a temperate and dry climate, where the temperature falls so quickly during the early part of the night. Thermometers exposed in a wooden screen lagging behind the true air temperature would there more likely read too high; but in Hongkong, where the temperature falls so very slowly during the night, and is even frequently rising a little between sunset and 10 p.m., the readings depend solely on the exposure of the thermometers. Thermometers exposed in an unpainted wooden screen placed on an open grass plot, would, perhaps, read slightly too high in the evening, even in a tropical climate; and from experience gained here I would suggest this as a most satisfactory exposure of thermometers for ordinary use. A metallic screen causes the thermometers to read too low during the night. The Stevenson screen being covered with a thick coating of white lead, partakes of the nature of a metallic screen, as white lead has the same radiating power as lamp-black, according to Leslie."

The thermometers are placed 4 feet above the ground, and the rims of the 8 inch rain-gauges are 1 foot above the ground. The cistern of the barometer at South Cape is 121 feet above sea-level. The heights of the mercury and the rainfall are expressed in inches, the temperature in degrees Fahrenheit, the relative humidity in percentage of saturation, and the force of the wind according to Beaufort's scale (0—12). The wind force appears to be correctly estimated at Ichang, or at any rate not under-estimated. At South Cape it is probably a little under-estimated. It will soon be possible to ascertain the latter fact by comparison with the anemograms now being taken at that important point.

At Ichang the instruments (including the rain-gauge) are read at 8 a.m., 9 a.m., 8 p.m., and 9 p.m., and the means given in Table I. are the means of the readings at those hours. The maxima are read at 9 p.m., and the minima at 9 a.m. At South Cape the instruments are read at 3 a.m., 6 a.m., 9 a.m., noon, 3 p.m., 6 p.m., 9 p.m., and midnight, and the means in Table II. are the means of the readings at those hours. The extreme temperatures are read at 9 a.m., the maxima being entered to the preceding day. The rainfall is read at 9 a.m. and entered to the preceding day. The amount of cloud is indicated by the letters *b*, *c* or *o*, which are here assumed equal to 1, 5 and 9-tenths of sky clouded (Comp. *Instructions*, page 24).

At Ichang the variations of pressure, both periodic and non-periodic, are twice as great as at South Cape, so that a high or rising barometer at the former station indicates increasing North-east winds along the South-east coast of China, and a low or falling barometer increasing South winds along the coast. The daily variation of pressure is smallest at Ichang.

The mean temperatures during the hottest part of the year are about the same at all Chinese stations south of the Yang-tze-kiang. The values for Ichang are, moreover, probably as much as nearly 2° too high, while at South Cape the error cannot amount to as much as 1°. The air temperature during the hottest part of the afternoon is, however, greater in the north, although, perhaps, about a third of the difference between the figures must be attributed to effects of radiation. The mean daily range at Ichang is given as 15°·4, which is of course several degrees too much, the excess being caused by radiation, particularly in the summer months. The mean range, 8°·9 at South Cape, requires a correction of −2°, which is seen to bring it down to the value of Hongkong. But even so, the great difference between the inland and coast climate remains conspicuous. Also the monthly extremes are much wider apart inland. The temperature at Ichang varied 85° in the course of the year. The intensity of solar radiation is of course greatest at the southern station—also in summer, as the length of the day does not affect the value of the maximum; for, although the black bulb *in vacuo* may be considered a sluggish instrument, it is never more than about twenty minutes behind. The reason why curves for black-bulb and duration of sunshine resemble each other must be that it is hottest in the sun on very clear days. The grass minimum thermometers appear to be practically useless. In order to obtain information about terrestrial radiation, a black

TABLE I.

ABSTRACT OF METEOROLOGICAL OBSERVATIONS AT ICHANG, CHINA, 1888.

Months.	Barometer.	Air Temperature.							Black Bulb Therm. *in vacuo*.		Min. Therm. on Grass.	
		Mean.	Means of		Absolute Min. and Max.				Mean.	Max.	Mean.	Min.
			Min.	Max.	Min.	Date.	Max.	Date.				
	In.	°	°	°	°		°		°	°	°	°
January	30·22	41·6	36·2	49·2	27·6	31	72·	6	74	122	33·5	25·2
February	30·20	39·0	33·8	46·6	22·0	12	60·1	27	83[2]	111	32·5[2]	24·0
March ..	30·01	53·6	47·3	63·0	40·9	20	78·0	24	100	132	45·4	37·5
April	29·82	62·5	56·6	70·9	46·5	2	82·0	17	106	134	55·2	45·5
May	29·74	71·5	64·0	81·6[1]	55·2	4, 5	96·8	16	117	149	63·0	52·2
June	29·59	80·5	72·8	91·0	64·2	3	98·5	17, 18, 20	138	156	71·9	64·9
July	29·55	83·6	76·4	94·8	69·3	4	107·2	11	143	156	76·2	69·6
August ..	29·57	83·1	76·8	94·5	72·7	22	101·5	4	144	159	76·6	72·1
September	29·87	75·8	69·9	84·8	61·2	15, 21	97·4	3	127	151	70·2	61·1
October ..	30·04	67·0	60·5	77·2	50·4	25	87·4	13	122	144	60·5	50·1
November	30·12	56·7	51·5	64·6	44·1	23	76·4	6	94	132	51·3	45·6
December	30·15	47·4	42·7	55·2	36·1	27	59·9	14	83	115	40·6	33·1
Year ..	29·91	63·5	57·4	72·8	22·0	Feb. 12	107·2	July 11	111	159	56·4	24·0

Months.	Relative Humidity.	Amount of Cloud.	Rainfall.				Wind, No. of Days of							
			Total Fall.	Greatest Fall in 24 hours.		No. of Rainy Days.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
				Amount.	Date.									
	o/o		In.	In.										
January	77	5·8	2·52	·45	29	13	0	0	4	17	3	2	1	3
February	81	5·1	1·68	·75	29	7	0	0	3	19	3	1	0	2
March	78	4·7	3·61	·96	26	11	0	0	0	22	3	0	2	3
April	82	5·0	5·10	1·00	22	14	1	1	1	18	3	0	0	4
May	76	3·3	4·40	1·69	20	11	0	0	4	19	3	0	0	4
June	72	2·8	2·02	·64	23	8	0	0	3	18	5	1	2	0
July	80	2·8	7·11	2·11	16	10	0	0	3	20	4	0	2	2
August	79	3·1	6·70	2·16	29	9	0	1	1	13	8	0	4	4
September ..	78	4·3	7·56	6·38	4	5	0	2	4	13	2	1	3	2
October	76	3·7	2·64	1·13	6	8	0	0	2	23	1	0	1	2
November	80	5·2	·52	·25	9, 28	3	0	0	1	24	2	1	1	0
December ..	82	4·4	·74	·48	31	6	0	0	1	24	1	0	0	2
Year	78	4·2	44·60	6·38	Sept. 4	105	1	4	27	230	38	6	16	28

[1] 30 Days only. [2] 28 Days only.

bulb thermometer (not self-registering) in the focus of a bright metallic reflector, the axis of which can be directed anywhere, appears to be necessary (Comp. *Nature*, Oct. 25, 1888).

The relative humidity is greatest at South Cape, and the difference is probably a little larger than appears from the figures. At this station the weather is much drier during the height of the North-east Monsoon than during the typhoon season, but at Ichang there is no pronounced annual

TABLE II.

ABSTRACT OF METEOROLOGICAL OBSERVATIONS AT SOUTH CAPE, FORMOSA, 1888.

Months.	Barometer.	Air Temperature.							Black Bulb Therm. *in vacuo*.		Min. Therm. on Grass.	
		Mean.	Means of		Absolute Min. and Max.				Mean.	Max.	Mean.	Min.
			Min.	Max.	Min.	Date.	Max.	Date.				
	In.	°	°	°	°		°		°	°	°	°
January	30·11	69·2	65·0	73·6	55·4	1	79·9	30	132	140	62·8	52·8
February	30·06	68·0	63·0	72·7	47·2	4	80·7	16	131	142	60·8	42·0
March ..	30·02	73·3	69·2	79·2	59·6	5	84·7	17	135	147	65·7	56·2
April	29·93	77·6	73·3	84·4	65·4	12	88·5	30	141	155	69·7	65·0
May	29·85	80·9	76·4	86·7	72·0	24	90·1	10	143	153	73·7	70·6
June	29·75	80·9	76·9	85·4	68·0	4	89·5	30	141	152	75·2	66·3
July	29·72	82·9	77·8	86·5	71·1	8	89·8	3	145	153	75·3	70·8
August ..	29·73	81·4	76·6	84·5	70·1	17	89·5	2	137	154	74·4	69·8
September	29·86	80·6	76·1	85·9	72·6	22, 23, 28	88·9	21	142	157	72·6	68·8
October ..	30·00	77·8	74·1	81·7	69·6	22, 23, 29	85·9	4	144	155	71·4	66·8
November	30·03	74·8	71·5	79·0	67·5	27	83·4	1	138	152	68·8	64·7
December	30·07	71·4	67·7	75·3	58·6	27	81·8	20	135	145	65·5	58·8
Year ..	29·93	76·6	72·3	81·2	47·2	Feb. 4	90·1	May 10	139	157	69·7	42·0

Months.	Relative Humidity.	Amount of Cloud.	Rainfall.				Wind, No. of Days of							
			Total Fall.	Greatest Fall in 24 hours.		No. of Rainy Days.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
				Amount.	Date.									
	o/o		In.	In.										
January	78	4·8	1·32	·71	14	6	7	22	1	0	0	0	0	1
February	82	4·9	4·01	1·14	10	12	12	13	0	1	0	0	0	3
March	88	4·8	1·36	·78	24	6	9	12	3	3	1	0	2	1
April	83	4·6	·69	·29	6	6	7	7	1	3	1	2	7	2
May	83	4·7	3·98	·98	21	12	5	6	0	1	2	2	9	6
June	87[1]	5·3	10·17	1·68	15	17	2	5	2	1	1	7	8	4
July	84	4·9	10·82	2·77	7	16	7	11	4	1	0	1	5	2
August	86	5·5[2]	12·46	2·85	7	13	4	2	0	0	6	4	9	6
September ..	83	5·1	9·47	2·27	26	15	11	15	1	0	0	0	3	0
October	80	4·9	·73	·30	7	5	9	16	0	0	0	0	2	4
November	85	5·2	10·95	8·00	18	11	9	19	0	0	0	0	0	2
December	80	5·0	2·17	·70	20	8	7	21	1	1	0	0	0	1
Year	83	5·0	68·13	8·00	Nov. 18	127	89	149	13	11	11	16	4	3 2

[1] 29 Days only. [2] 30 Days only.

variation of relative humidity. The absolute humidity increases, of course, greatly in summer. The relative humidities here given are calculated by aid of Blanford's tables, which are the best; but as they are nearly adapted for use with the rotating thermometers, it follows that they furnish too great humidities when the psychrometer is placed in a screen without artificial ventilation. On the other hand, it is impossible to adapt tables to the circumstances in the screen without having the wind force registered at each obser-

vation by a small anemometer placed inside the screen, and using a different set of tables for each wind force.

The amount of cloud is greatest during the winter at Ichang. This result was unexpected. There is not much difference between the single months at South Cape in that respect, but perhaps it may be a little cloudier in summer, which is the rainy season at both stations. On the east coast of Formosa it is clearest in summer, while on the west coast it is clearest in winter.

At South Cape the North-east Monsoon prevails during upwards of eight months. In summer the mean direction of the wind is largely influenced by typhoons. At Ichang the mean direction does not differ much from South-east, which is due to the Yang-tze-Kiang, the wind having a tendency to blow along such rivers. That is remarked on every journey along its banks, the wind changing every time the river makes a bend.

The maximum wind force means the greatest daily mean force. It is least at the inland station because typhoons cease to blow very hard as soon as the storm enters the mainland. Probably the freshest winds experienced at Ichang are due to thunder-squalls.

[The following Sunshine Values have been received from Dr. Doberck since the above paper was read; they are appended hereto, as they afford additional information for the year 1888.—ED.]

SUNSHINE AT SOUTH CAPE AND HONGKONG.

A Sunshine Recorder was fixed at South Cape in March 1888. The following are results for the twelve months, April 1st, 1888, to March 31st, 1889, to which are added the corresponding values for Hongkong.

		South Cape.		Hongkong.	
		No. of Hours of Recorded Sunshine.	Percentage of Possible Duration.	No. of Hours of Recorded Sunshine.	Percentage of Possible Duration.
April	1888	236·0	67	127·9	36
May	,,	228·2	60	128·9	34
June	,,	167·8	45	93·9	25
July	,,	283·8	74	250·9	65
August	,,	203·0	55	210·2	57
September	,,	205·7	60	198·2	58
October	,,	241·2	73	183·3	55
November	,,	206·1	67	200·4	65
December	,,	154·2	50	147·8	48
January	1889	134·4	43	77·0	25
February	,,	199·8	68	125·5	43
March	,,	183·5	53	41·7	12
Year		2443·7	60	1785·7	44

It appears that there is only three-quarters as much sunshine at Hongkong as at South Cape, which is a very sunny place. There is only a trace at the latter station of the marked annual variation which obtains at Hongkong, where clear weather prevails in autumn and overcast skies in spring.

METEOROLOGICAL PHENOMENA OBSERVED DURING 1875-87 IN THE NEIGHBOURHOOD OF CHELMSFORD.

By HENRY CORDER.

(Communicated by G. J. Symons, F.R.S., Secretary.)

[Received April 17th.—Read June 19th, 1889.]

The accompanying Tables are compiled from a series of observations made, in the first part of the period at Writtle, which is about 2½ miles South-west of Chelmsford, and after September 1880, at Great Baddow, a village about the same distance South-east of Chelmsford; but during the first part of the time I was indebted to Mr. W. Impey of Broomfield Hall, 2 miles North of Chelmsford, for the rainfall returns.

In the tables of wet days, it was my custom to record even the slightest shower, so that the number of wet or snowy days appears larger than it would have done if I had only recorded those as "wet" on which a measurable amount of rain fell.

One of the most interesting of the tables is that recording the number of solar halos, and it is my opinion that these phenomena do not to any great extent presage rain, as is commonly supposed, but that the most brilliant ones are commonest in April and May, in seasons when the spring is cold and dry. They may, however, be possibly divided into dry and wet halos, the latter being generally ill-defined and with very faint arcs above and touching them, whilst those in dry weather are clearly defined, but the halo itself is faint in comparison to the upper tangential arc. This arc appears curved upwards at sunrise or sunset, it then gradually straightens, and when the sun is high the ends hang downwards, occasionally joining another arc from below forming an oval halo outside the circular one. On one occasion the two halos were concentric. Only 17 observations of the great halo were made, and 12 of the circumzenithal arc which forms a rainbow-coloured circle touching the great halo. Mock suns were observed on 157 days, or about once a month, and their maximum is about 6 weeks earlier in the year than that of the halos. Only one observation of mock moons was made. In conclusion, I would wish to call the attention of observers to these phenomena, which,

owing perhaps to the brilliancy of the bodies causing them, are apt to be overlooked.

Rain.—The wettest month is November, and the driest June. The wettest year was 1879, the driest 1887.

October shows the most rainy days, and February the fewest, and 1877 in this case the most instead of the very wet year 1879.

Snow is observed oftenest in January, only once in May, and then not again until October with only 3 observations. It was much the most abundant in 1879, but in the winter of 1881-1882 only on 7 days.

Hail is rather difficult to separate from hard snow, but care has been taken to keep free from this error, and March, April, and May show the highest records, while in July, August, and September it is least frequent. It is only observed on about 10 days a year.

Frosts registered on the ground were most numerous in 1879 and 1887, and are more frequent in January. The single record for July was not a very certain one, but there was no doubt a frost in low-lying places on that occasion. March shows more than February, even in larger proportion than the shortness of the latter month would account for.

Fogs show a very regular increase from July to their maximum in December and January, but seem more numerous in June than in the month before and after it.

Solar Halos have been carefully observed, 1081 having been noted in 13 years, an average of 83 per year. These include only the ordinary halo at about 22° distance, but the small arc touching on the upper part has sometimes been taken to indicate a halo. This arc is of less radius at sunset or sunrise, straightening out when the sun is higher and becoming curved downwards at midday in summer. On one occasion a double halo resulted from the joining of arcs above and below, and once the ring appeared completely double (this was not the great halo at 46°). They are most vivid and frequent in dry cold weather in the spring, and when the arc is brightest are more a sign of dry and cold weather than wet.

Mock Suns were observed 157 times, and are also commonest in the cold spring time, though rather earlier in the year than the halos. March shows the highest record for them, whereas it is April and May for the halo.

Thunder and Lightning were most observed in 1878, and least in 1887. This was partly owing to less notice being given to summer lightning at night. It is most abundant in July and August, and least so in February.

Rainbows were observed on 207 days in 13 years, and seem distinctly most numerous in July, which is curious, as the sun is then too high during a greater part of the day to show them; it probably shows that thunder showers are commonest in that month in the evening just before sunset.

Windy Days, i.e. when the force of wind was equal to about 5 of a scale of 12.—March and April show the highest records, although the winds were not so violent as in the autumn gales.

Rainfall.—Table III. shows the distribution in the various months, although not all registered at the same place, the villages being about 5 miles

apart. The first 6 months show an average of under 2 inches, March being the driest and October the wettest. This was partly owing to the heavy local fall of nearly 3 inches in October 1880.

The wettest year was 1879, the driest 1884.

Auroras (including auroral glows without streamers).—This phenomenon seems decidedly most common in November, although rather remarkable examples were seen in October and March. They were more abundant before this table commences, especially in 1870, 1871, 1872 and 1873, during the time of the sun-spot maximum, which was not so well marked in 1880.[1]

Thunderstorms within a mile.—This record was commenced because, owing to irregular watches for shooting stars and astronomical observations, summer lightning would probably be more noticed in some months than others, and so give a wrong idea of the number of actual thunderstorms. Thus it shows July to have the most thunder, although more lightning was observed in August.

Red Sunsets seem to be most abundant in the latter half of the year. August shows the highest total, but nothing very marked is observable in this register.

"*April Showers.*"—As the record has only been kept for 6 years the results are not of much value, but they tend to show that May rather than April is the month of showers, but this is partly owing to the unusually high number in 1885—18 days in the month.

Notes on Thunderstorms.

July 11, 1872. A close afternoon followed by tremendous storms; I counted 49 flashes in one minute. 2½ inches of rain.

July 5, 1877. An Elm tree struck at Writtle (Essex), the top twig killed, and a narrow slit made in the bark to the ground, which was slightly upturned.

July 6, 1877. An Oak tree struck at Writtle, the stem, 4 ft. in circumference and 12 ft. high, being completely barked, and though still left standing the wood was entirely split up into shreds.

July 28, 1878. Thundercloud very high up and peals lasting for at least 1¼ minute—one, indeed, for 2 minutes, but perhaps from two flashes.

June 30, 1878. Thunderclouds very low and peals very short.

August, 1878. A series of storms on several days. Colour noted. One evening at 9 p.m., storm distant 20 miles and lightning very purple. Next night a nearer one and lightning green, yellow, and purplish white.

August 28, 1878. Violent storm over Chelmsford, a windmill and 2 houses struck. Thunder in loud explosions.

September 8, 1878. Storm north of Saffron Walden, the thunder heard near Chelmsford. Time between flash and thunder from 70 to 130 seconds.

August 2, 1879. Very heavy storms of hail over the country and great damage. Counted 1611 flashes in 71 minutes in the night; highest number 44 in one minute. Only 0·21 in. of rain, but at Cambridge 8½ inches.

[1] The sunspot maximum was in 1883.—*Ed.*

TABLE I.—MONTHLY FREQUENCY OF METEOROLOGICAL PHENOMENA OBSERVED IN THE NEIGHBOURHOOD OF CHELMSFORD, 1875–1887.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Rain Snow or Hail	16·9	16·6	15·3	17·3	16·5	14·0	16·4	15·9	16·4	17·5	18·5	18·1	199·4
Rain (however little)	12·7	13·3	11·5	16·4	16·2	14·0	16·3	15·8	16·3	17·4	17·3	15·3	182·5
Snow	6·2	4·2	5·8	1·8	0·1	..	..	..	..	0·2	2·4	5·5	26·2
Hail	0·6	0·8	1·8	2·2	1·8	0·6	0·3	0·2	0·3	0·5	0·4	0·8	10·3
Frost on the Grass	17·0	12·1	15·1	9·5	5·0	0·4	0·1	0·5	1·2	5·7	10·2	14·5	91·3
Fog	5·5	2·4	2·3	1·0	0·4	0·9	0·6	1·7	3·6	4·0	4·0	5·1	31·5
Thunderstorms (including distant Lightning)	0·7	0·4	0·9	2·2	3·5	4·2	5·5	5·9	4·4	2·9	1·8	1·4	33·8
Thunderstorms within 1 mile (7 years)	0·1	..	..	0·1	0·4	0·9	1·1	0·6	..	0·3	..	..	3·5
"April Showers" (6 years)	0·7	2·0	5·8	6·7	8·7	4·0	5·3	4·0	4·7	4·0	3·8	3·8	53·5
Windy Days (=5 of scale of 10)	7·0	7·0	8·2	7·8	6·5	4·0	4·6	3·8	5·1	7·6	7·6	6·3	75·5
Rainbows	0·3	0·8	1·0	1·4	1·9	1·2	2·3	1·5	1·6	1·7	1·5	0·7	15·9
Red Sunsets	3·9	3·7	2·9	4·5	2·8	4·1	4·1	6·8	4·0	5·0	4·9	3·8	50·5
Solar Halos	4·5	5·6	8·5	10·0	10·0	7·5	7·2	6·7	6·8	5·9	6·3	4·2	83·2
Mock Suns	1·1	1·3	2·1	1·6	0·8	0·3	0·5	0·5	0·6	0·8	1·4	1·1	12·1
Aurora	0·3	0·2	0·7	0·5	..	..	0·1	0·2	..	0·5	1·7	0·6	4·8

TABLE II.—YEARLY FREQUENCY OF METEOROLOGICAL PHENOMENA OBSERVED IN THE NEIGHBOURHOOD OF CHELMSFORD, 1875–1887.

	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	Avge.
Rain, Snow, or Hail	201	213	227	214	248	186	186	206	193	173	180	180	163	199·4
Rain (however little)	176	187	219	197	207	179	186	204	187	166	172	153	146	182·5
Snow	35	31	20	29	59	15	25	10	23	17	10	38	28	26·2
Hail	9	5	14	10	13	4	7	10	10	14	15	10	14	10·3
Frost on the Grass	65	69	71	82	126	92	99	75	82	74	112	118	124	91·3
Fog	29	26	24	33	41	42	23	36	41	23	25	41	29	31·5
Thunderstorms (including distant Lightning)	35	32	35	55	29	40	23	46	33	47	22	27	17	33·8
Thunderstorms within 1 mile	..	..	..	..	..	..	4	4	4	8	1	1	3	3·5
"April Showers"	..	..	..	..	..	..	..	53	55	37	47	46	83	53·5
Windy Days (=5 of scale of 10)	91	80	82	59	94	58	61	74	77	74	77	83	75	75·5
Rainbows	25	10	17	13	14	14	17	25	18	9	10	12	23	15·9
Red Sunsets	25	28	41	77	52	59	53	50	70	59	48	45	50	50·5
Solar Halos	96	67	93	99	82	106	79	94	87	67	62	77	72	83·2
Mock Suns	14	4	13	13	16	15	10	15	20	6	11	15	5	12·1
Aurora	7	5	2	11	2	6	2	11	8	3	4	2	0	4·8

July 1, 1880. Thunderstorm nearly overhead. One clap of thunder coming 11 seconds after lightning and lasting for 90 seconds.

July 8, 1880. Storm overhead. Some claps, coming only 4 seconds after lightning, began quietly, then went off with a sudden explosion shaking windows.

September 11, 1880. Storm at night. Flashes very persistent, some lasting in a flickering manner for 2 or 3 seconds.

TABLE III.—RAINFALL AT BROOMFIELD AND BADDOW, 1875–1887.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1875	1·99	·66	·47	1·25	2·00	3·62	4·40	·71	2·39	4·45	3·34	·86	26·34
1876	·80	2·02	2·73	1·71	1·16	1·44	·90	1·53	2·70	1·03	2·56	5·03	23·61
1877	4·13	1·74	3·09	2·82	1·81	·53	2·70	2·64	·90	1·85	3·21	1·74	27·16
1878	1·29	1·25	1·02	1·42	3·49	1·35	·65	4·76	·51	2·27	3·93	1·05	23·03
1879	2·28	2·70	·82	2·59	2·32	4·32	4·01	4·06	3·02	1·00	·59	·71	28·42
1880	·15	1·60	·66	1·69	·76	2·24	4·25	·58	2·95	7·33	2·51	2·66	27·38
1881	1·70	1·77	1·27	·73	·75	1·79	1·76	3·62	1·94	2·79	2·59	2·98	23·69
1882	1·12	1·02	1·18	2·62	1·24	2·44	3·45	1·49	2·36	4·89	2·79	2·88	27·48
1883	1·58	2·88	·99	1·82	1·73	2·54	2·11	·60	2·64	2·46	3·13	·95	23·43
1884	1·84	1·28	1·64	1·04	·47	1·21	1·79	·56	2·52	1·75	1·18	2·65	17·93
1885	1·46	2·64	1·70	1·47	2·38	1·62	·46	3·24	4·62	3·46	3·02	·62	26·69
1886	3·02	·15	1·24	1·12	2·46	·49	2·73	1·62	1·11	2·67	2·68	3·58	22·87
1887	1·78	·48	1·47	1·25	1·63	·54	1·68	2·24	1·94	1·38	3·87	1·31	19·57
Average..	1·70	1·55	1·41	1·66	1·71	1·86	2·38	2·13	2·78	2·87	2·72	2·08	24·43

October 8, 1880. Storm came over in morning. Thunder lasting from 70 to 80 seconds. Last clap 74 seconds after lightning.

July 5, 1881. Many storms all over the country at night. Claps of thunder lasted as long as 100 seconds.

April 5, 1882. Very interesting observation of distant thunder. Sky clear except a bank of cloud in South-east. I saw 3 bright flashes at long intervals, all followed by thunder which was sufficient to shake the windows. I only was able to count the time between one flash and the thunder, which did not come until 200 seconds after. This is by far the longest interval I ever noted. The other two flashes agreed as near as I could judge, but were unexpected and not counted. I think there is no possibility of error in this observation.

June 15, 1882. Another good instance of explosive thunder. Each time the clap commenced very gently, it being almost impossible to tell the exact moment; at from 5 to 20 seconds a violent explosion came, followed by several sharper ones, but getting less loud, till in from 30 to 50 seconds it rumbled gradually away.

July 1, 1883. I think it was on this date that a great thunderstorm occurred at Norwich in the afternoon, doing much damage—it went off in the direction of Yarmouth, I was told. In the evening of that day at Baddow (Chelmsford), from 9 until 11 p.m., we heard distant rumblings in the North-east, audible even in a closed room and almost continuous. Except for a very low bank of cloud in the North-east it was clear, and I could see no lightning, but the twilight in the North might have prevented. I wrote inquiring whether any storm had been seen or heard at Ipswich or Sudbury, but could hear of none, except a very doubtful account of one at Haughley in Suffolk. If so it was about 60 miles distant, but it remains a mystery.

August 9, 1884. Heavy distant storm; the first thunder noticed coming 145 seconds after the lightning.

August 28, 1886. Distant lightning at night. Newspapers reported storms at Paris and Rouen at that time, 9 p.m.

October 20, 1886. Heavy storms in Essex. Thunder bursting like cannon. The storm gathered over North Essex; the sky quite clear over Thames valley. One long flash travelled from North-west to East, throwing off branching flashes. The sound of the thunder evidently commenced at the terminal point, rolling back along the track to the commencement.

November 26, 1888. A very odd observation of lightning. A heavy hail shower passed over Bridgwater, and after a short time a brilliant flash of lightning appeared. I was looking on the ground, but after I looked up the flash was seen fading away exactly like the streak left by a meteor, but zigzag. Fortunately two other people observed it, so that I am able to assert positively that the flash was as it were left in the sky for an appreciable time without in any way altering in shape or position, but merely fading gradually. That it was not a case of persistence of vision is proved by my looking up after the flash and finding its "streak" left. Its zigzag character and obvious thunder also preclude the idea that it might have been a daylight meteor.

ON DAMAGE BY LIGHTNING AT HAMPSTEAD, ON MAY 23rd, 1889.

By G. J. SYMONS, F.R.S., Secretary.

[Read June 19th, 1889.]

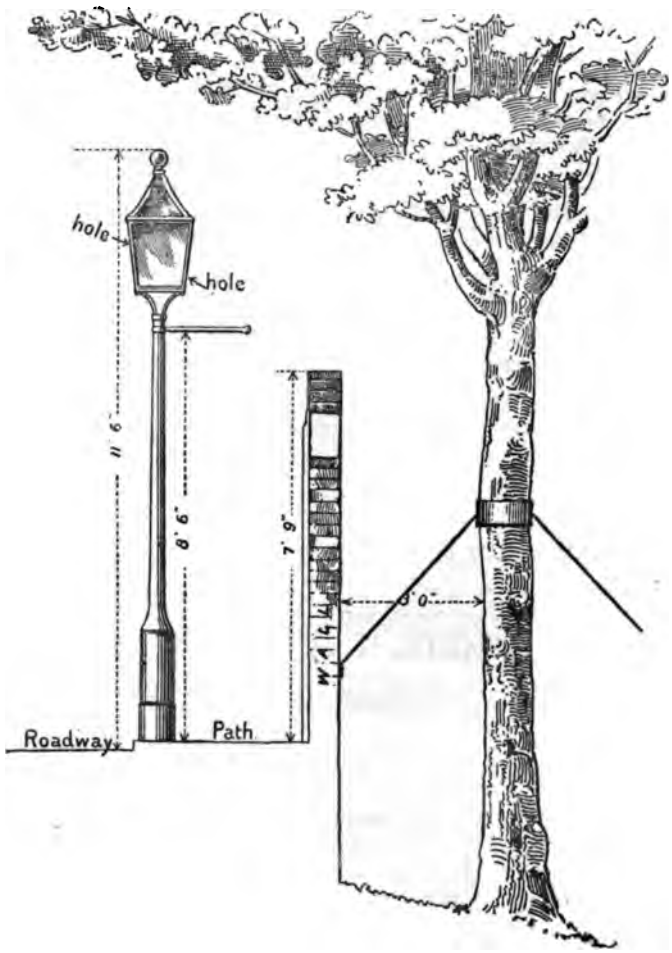
For information of the occurrence which I am about to relate, and for much help in attempting to understand what occurred, I am indebted to a Fellow of our Society, Mr. B. Woodd Smith, close to whose lodge gates the accident happened. Indeed the description might more appropriately stand in his name than in mine.

The circumstances present much parallelism with those of the injury to a street lamp near Bootham Bar, York, which is fully described with engravings in the *Report of the Lightning Rod Conference* (p. 219).

In the York cases the site of injury may be described as a hollow, if not almost a pit; in the Hampstead one the part in which the accident occurred is at least 30 feet below the top of Hampstead, and on a rapid slope; the actual site of injury is surrounded by trees and buildings considerably higher than itself and quite close to it.

It will be seen from the accompanying fig. that the branches of the tree actually covered the lamp post, and yet the tree shows no injury, and the damage was all done at the height of less than 11 ft. from the ground. The lamp post had the usual ladder-rest pointing towards the wall, and it at first sight seems curious that the wall is injured, not centrally opposite to the end of this ladder-

rest, but almost a foot below, and to one side of, it. The injury to the wall seems to have come from the roadside, because most of the bricks forced out were scattered over the garden. The ivy which covered the inside of the wall was also thrown over the beds, but that is probably not such strong evidence of direction as the position of the bricks.



The lamp, of the usual London pattern, was a square one, dropped into the square holder at the top of the lamp post. It is slightly broken at the bottom, but its chief injuries are on the sides, on that towards the wall is a hole of about ¾ of an inch diameter, rather below the centre of the pane. This hole, which is roughly circular, has evidently been made from the wall side, *i.e.* inwards, *not* outwards, because the edges are flaked off on the inside, and the fragments of glass are left on the bottom inside. There is a much larger hole in the opposite (or road side) pane; but, as the edges are broken clean, there is no evidence as to the direction whence this was broken. A fragment of brick was found in the lamp, but in my opinion much too small to have caused even the smaller hole, and *à fortiori* the larger, besides which, if the bit of brick were projected with such force as to pierce the first pane and break out the second, it would probably have passed through the latter and fallen to the ground.

In a case like this, it would be presumptuous to attempt any definite explanation; one can only safely state facts, and offer suggestions.

The injury occurred during heavy rain, when the tree, wall, ivy and everything else would be covered with water. There are several trees inside the wall, which at about 6 feet above the ground are supported by iron collars, whence wire guy ropes reached in several directions.

Possibly, the trees being so wet, received a slight flash of lightning without injury, and this would distribute itself over the collars and guy ropes.

The burner of the lamp (it was not alight, as the accident occurred about 5 p.m.) would be in perfect connection with the hundreds of miles of gas mains throughout the Metropolis, and a far better earth than the lamp post itself, which would be in connection with nearly dry earth only, and moreover probably very much covered with rust at every joint.

If this be the case, may there not have been two electrodes, one on each side of the wall? the electricity of the storm-cloud brought down the guy wires of the trees, and the electricity of the earth led up to the jet inside the lamp. Might not a disruptive discharge between these two account for the mischief?

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

MAY 15TH, 1889.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

THOMAS HENRY HALL, Hope House, Hebden Bridge, *via* Manchester, was balloted for and duly elected a Fellow of the Society.

The following Papers was read :—

"ACCOUNT OF SOME EXPERIMENTS MADE TO INVESTIGATE THE CONNECTION BETWEEN THE PRESSURE AND VELOCITY OF THE WIND." By W. H. DINES, B.A., F.R.Met.Soc. (p. 183.)

"WIND STORM AT SYDNEY, NEW SOUTH WALES, JANUARY 27TH, 1889." By H. C. RUSSELL, B.A., F.R.S. (p. 191.)

"ON AN IMPROVED METHOD OF PREPARING OZONE PAPER AND OTHER FORMS OF THE TEST, WITH STARCH AND POTASSIUM IODIDE." By C. H. BLACKLEY, M.D., F.R.Met.Soc. (p. 193.)

"ON THE CLIMATE OF AKASSA, NIGER TERRITORY." By FRANK RUSSELL, F.R.G.S. (p. 199.)

JUNE 19TH, 1889.

Ordinary Meeting.

WILLIAM MARCET, M.D., F.R.S., President, in the Chair.

THOMAS JAMES MOSS FLOWER, 1 Passage Street, Tower Hill, Bristol;
ALBERT HUBERT HALDER, F.R.I.B.A., Barberton, South Africa;
ROBERT ANDERTON NAYLOR, F.R.G.S., Cuerden Hall, Thelwall, Warrington; and
CHARLES BERKELEY PENLINGTON, Assoc.Mem.Inst.C.E., Apartado 82, Bilbao, Spain,
were balloted for and duly elected Fellows of the Society.

The following Papers were read :—

"THE CLIMATE OF BRITISH NORTH BORNEO." By ROBERT H. SCOTT, M.A., F.R.S. (p. 206.)

"THUNDERSTORMS OF JUNE 2ND, 6TH AND 7TH, 1889." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 219.)

"ON THE VARIATION OF TEMPERATURE OF THE AIR IN ENGLAND DURING THE PERIOD 1849 TO 1888." By WILLIAM ELLIS, F.R.A.S., F.R.Met.Soc. (p. 228.)

"ATLANTIC WEATHER AND RAPID STEAMSHIP NAVIGATION." By CHARLES HARDING, F.R.Met.Soc. (p. 235.)

"METEOROLGICAL PHENOMENA OBSERVED DURING 1875-87 IN THE NEIGHBOURHOOD OF CHELMSFORD." By HENRY CORDER. (p. 245.)

"RAINFALL IN CHINA ; AND METEOROLOGICAL OBSERVATIONS AT ICHANG AND SOUTH CAPE IN 1888." By W. DOBERCK, Ph.D., F.R.Met.Soc. (p. 239.)

"ON DAMAGE BY LIGHTNING AT HAMPSTEAD, ON MAY 23RD, 1889." By G. J. SYMONS, F.R.S. (p. 250.)

CORRESPONDENCE AND NOTES.

SILVER THAW.

IN the discussion on Mr. Plowright's paper on Rime Frost (p. 139), it seemed to be assumed that Silver Thaw was occasioned by the freezing of rain by contact with cold surfaces, such as the earth, branches of trees, herbage, &c.

I have had several opportunities of observing this phenomenon, and have been struck by the thickness of the deposit on bodies having little capacity for heat, and moreover of great tenuity. Blades of grass, for instance, have received a coating of clear ice of the thickness of a penny piece.

Small twigs have increased to three times their original diameter, and so on. It was evident to my mind that mere conduction of heat would not explain the phenomenon, but that some other cause must be looked for.

That cause is, I beg to suggest, none other than superfusion ; the substance that falls is not water, but *superfused ice*, which only needs the contact of a nucleus to at once crystallise, as is the case with many other substances known to physicists. Superfusion is closely analogous with supersaturation, but has not, I believe, attracted the same amount of attention.

THOS. B. GROVES, F.R.Met.Soc.

INFLUENCE OF FORESTS ON THE CLIMATE OF SWEDEN.

DR. H. E. HAMBERG has recently issued Part III. of his work on this subject, which consists of a series of reports on investigations carried out at the Central Meteorological Institute, Stockholm, at the joint expense of the Swedish Woods and Forests Department, and of the Society of Rural Economy of the Government of Upsala. The author again draws attention to the fact that his results apply only to Sweden.

The following are the conclusions at which he arrives :—

The excess of water supplied to the atmosphere by the forest vegetation, above that which would be supplied by the same area of bare soil, is certainly considerable, and if that amount of vapour remained over the forest or was restored to the soil in the form of rain, it would be of great utility, but the wind carries this vapour away and disperses it on all sides, so that its useful

effect to our own country is scarcely if at all perceptible. Accordingly, the difference of absolute as well as of relative humidity between the cultivated patches in our extensive forest districts and the cultivated plains of our country is very slight or almost *nil.* It is true that relative humidity is greater under trees than in the open plain; but as there is no tillage under trees, and as the relation mentioned does not apply to open spaces surrounded by wood, this difference in humidity can have no practical importance.

In our opinion the lakes and large swamps as well as the marshes have a much greater influence on atmospheric humidity than the forests. The evaporation from the latter, for equal areas, is far less than from the former. The draining of lakes and swamps has not been regarded with serious alarm. Supposing that the atmospheric humidity were slightly diminished by the disappearance of all the forests, as well as of all lakes and swamps, the question might be asked as to whether vegetation would suffer materially. We know well that it is not proved that plants absorb anything directly from the humidity of the air, and so it makes very little matter if that humidity is a little higher or a little lower. In the second place, we know that the humidity may vary considerably in different years, without any deleterious effect on vegetation if the other conditions are favourable to its growth.

This is not the place to inquire if the humidity would suffer by such a disappearance of forests and lakes as mentioned above. In the moist atmosphere surrounding the island of Gothland, the vegetation in several years suffers as much or even more from dryness than the soil. This dryness is not due to reduced humidity of the air, but to the action of the wind and absence of rain. The complaint is made, and perhaps justly, that this dryness has become more serious since the deforestation, which has been very extensive in that island. I do not discuss the question, which has not yet been answered, as to whether the rain has diminished owing to this deforestation. It is quite certain that the forests were useful to Gothland in a very different way, as affording shelter against winds which dry up the soil and damage the crops. One effect of forests on atmospheric humidity, which seems to be useful to vegetation and agriculture, is the increase of dew in clearances. But this increase of dew is not attributable to a greater abundance of vapour in the forests, but to the increase of terrestrial radiation induced by the forest. And this cooling effect may easily bring on another danger, that of hoar frosts, of which already we have more than enough in our forest districts.

The nocturnal diminution of temperature in a locality and the tendency to the production of hoar-frosts, which are closely related to each other, are fortunately counterbalanced by agriculture. In an open space surrounded by forests we can often see hoar-frost on the uncultivated herbage, while on a field hard by with rye in full flower the temperature is much above zero both at the root and at the ear of the corn. But this higher temperature has been gained at the expense of the dew, inasmuch as tillage carries on a struggle with that useful meteorological factor. Here, as in many other cases where man intervenes in the course of nature, the fact of experience is confirmed that one advantage is secured at the expense of another, or that one soil is introduced as another is removed. For this reason the agriculturists of Småland and of Jemtland have preferred bare dry elevated lands, exposed to wind, to fields at a lower level wooded and moist, but more subject to frost. A farmer who has command of artificial irrigation, and whose lands are protected against noxious winds by mountains or by any screen, natural or artificial, looks on the forests which surround him and shut off his sunlight with very different eyes from those of another, obliged to till an island or an open plain exposed to bitter winds.

If all the forests were cleared what would be the result for the atmospheric humidity in Sweden? Supposing that this clearance did not materially modify the quantity of rain that falls, and it is not proved that it would, it seems to us that the amount of vapour contained in the stratum of air in which we live would not be altered in a way which would materially influence vegetation. Probably relative humidity would be slightly reduced in summer, because temperature would probably rise slightly.

RECORD OF THE RAINFALL FOR FIVE YEARS TAKEN AT FRERE TOWN, THE ENGLISH MISSION STATION AT MOMBASA (Communicated by the Meteorological Council.)

Copied from Meteorological Log, kept by G. D. TREVOR-ROPER, Surgeon, on board H.M. Surveying-Vessel *Stork*, Commander T. F. PULLEN.

Months.	1876.	1877.	1878.	1879.	1880.
	In.	In.	In.	In.	In.
January	0·35	0·25	7·66	0·57	0·00
February	0·18	0·00	0·51	3·17	0·36
March	3·57	3·71	4·75	1·39	1·96
April	6·00	4·50	12·46	10·50	6·31
May	16·16	12·82	4·46	16·36	9·62
June	3·11	6·71	8·08	4·31	1·01
July	4·60	4·10	1·09	2·20	9·45
August	2·68	9·79	4·26	1·81	1·39
September	2·66	10·75	3·09	1·25	0·15
October	0·97	12·44	3·04	0·44	4·39
November	0·56	21·05	2·09	3·02	6·26
December	0·60	3·49	0·03	0·55	1·76
Totals	41·44	89·61	51·52	45·57	42·66

South-west Monsoon commences in March or April.
North-east Monsoon commences in September or October.

SOUTH AMERICAN RAINFALL SOUTH OF THE TROPICS.

MR. W. B. TRIPP, F.R.Met.Soc., in the June No. of the *Scottish Geographical Magazine*, has a paper on South American Rainfall, which is illustrated by a very good map showing the mean annual distribution of rainfall. The records of rainfall for the continent of South America are very few. Mr. Tripp has, however, made good use of them, and finds that the rainfall in this part of the world presents several characteristics very similar to those exhibited in that of those parts of the Cape of Good Hope which occupy respectively similar latitudes Like the southern part of Africa, the two opposite coasts of South America are exposed to different rain-producing winds, the monthly falls in different parts attaining their maxima at different seasons of the year. The principal rainfall also along the opposite coasts culminates in different latitudes, while in the extreme north-western region there is in both cases an almost rainless area.

The east coast of South Brazil, Uruguay, and the northern portion of the Argentine Republic, are exposed to the South-east Trade winds, and the rainfall attains its maximum in the spring and summer months. This occurs particularly in the sub-tropical inland regions.

As higher latitudes are reached, the fall becomes more equally distributed throughout the year, and the amount decreases from over 60 inches at Uberaba to probably some 10 inches or less in parts of Patagonia.

In those parts of the Argentine Republic lying between Chubut, where the fall, so far as hitherto recorded, appears to be under 20 inches, and the few rainfall stations round Cape Horn and the Falkland Islands, where the fall appears to be over 20 inches, there appear to be no complete records of rainfall existing; there seems, however, to be every probability that the annual fall dwindles to very small proportions in some of the regions.

The west coast has its principal fall in the latitudes of the Anti-trades. For some 6° or 7° to the south of about 37° south latitude an extremely heavy rainfall occurs in the winter months, brought by winds from the North-west, the amount reaching to an annual fall of, in some cases, over 100 inches, some 24 or 25 inches of which occur in the month of July.

This is all precipitated within a short distance of the coast, against the steep declivities of the Andes, leaving nothing but dry rainless winds to descend the other side on to the arid plains of Patagonia.

The same thing occurs in an opposite direction in the north-western rainless region of which mention has previously been made.

The moisture being entirely condensed from the South-east Trades on the eastern slopes during their passage over the Andes, these winds as they descend the opposite sides have acquired the extremely dry character which is so well known as being characteristic of Peru and part of Bolivia, and which has produced such remarkable and well-known local phenomena.

The condition of winds and currents along the north-west coast are utterly unfavourable to any rainfall coming from the sea. In Patagonia, on the other hand, the meteorological conditions along the south-east coast appear to be more favourable for producing some degree of rain. There appears, however, to be every probability that the south-western coast has a much more abundant rainfall than the south-eastern, even to the southward of the heavy rainfall districts of Chili above referred to. It also appears very probable that lying between the eastern and western coasts of Patagonia there is a dry belt getting little rain from either side.

RECENT PUBLICATIONS.

AMERICAN METEOROLOGICAL JOURNAL.—July-September 1889. Vol. VI. Nos. 8-5. 8vo.

The principal original articles are :—Storms and a central ascending current, by Prof. H. A. Hazen (7 pp.). In this paper the author states the principal arguments for and against the existence of a central ascending current in connection with cyclones. The arguments *for* are well known, but Prof. Hazen argues strongly *against* the idea, stating that the rainfall is not heaviest at the centre, and that tornadoes do not occur there. He declares that the laws of diminution of temperature with height are not sufficiently known, that meteorology requires quantitative analysis, and positive calculations of cause and effect, and that at present balloon observations are urgently required.—The organisation of the Meteorological Service in some of the principal countries of Europe, by A. L. Rotch (11 pp.). In this No. the author gives an account of the meteorological system in Holland.—Anemometer studies, by Prof. C. F. Marvin (6 pp.). This is a rejoinder to some remarks by Prof. Hazen on the anemometric experiments of himself and of Mr. Dines. He comes to the conclusion that the Robinson anemometer is more trustworthy than the English experiments seemed to show. The main subject of discussion is the influence of the natural wind at the time of the whirler experiments.—State Tornado Charts, by Lieut J. P. Finley (27 pp.). The charts now given are for Iowa, Kansas, Indian Territory, Alabama, and Ohio.—Decrease of temperature with increase of altitude, by Prof. W. Ferrel (5 pp.).—Some diurnal and annual oscillations of the barometer, by H. H. Clayton (3 pp.).—Saussure on the use of the sling thermometer (5 pp.).—Atmospheric economy of solar radiation, by A. Searle (7 pp.).—Cloud formation, by Prof. H. A. Hazen (7 pp.).—Verification of Weather Forecasts, by H. H. Clayton (9 pp.).

ANNUAIRE DE LA SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE. January-June 1889. 4to.

The principal articles are : Relations entre les mouvements barométriques et les positions de la lune et du Soleil dans l'année météorologique 1883, par A. Poincaré (6 pp.).—Compte rendu du service hydrométrique du bassin de la Saône pour l'année 1887, par M. Remise (2 pp.).—Résumé des observations centralisées par le service hydrométrique du bassin de la Seine, pendant l'année 1887, par M. Babinet (32 pp.).—Remarques théoriques sur les mouvements gyratoires de l'atmosphère, par H. Lasne (14 pp.).

BRITISH RAINFALL, 1888. By G. J. SYMONS, F.R.S. 255 pp. and 5 plates. 8vo. 1889.

This valuable work now contains the records of rainfall from 2590 stations distributed over the British Isles. The year 1888 had much dry weather yet few

droughts; hours and days of excessive rain, and months with amounts of rain almost without precedent, yet the total was decidedly below the average. The greatest amount in the year, 175·4 ins., was measured at the Stye, Cumberland, and the least, 17·5 ins., at Skegness, Lincolnshire.

JOURNAL AND PROCEEDINGS OF THE ROYAL SOCIETY OF NEW SOUTH WALES. Vol. XXII. Part 2. 1888. 8vo.

This contains four papers by Mr. H. C. Russell, viz.—1. An improvement in anemometers (3 pp.). 2. The storm of 21st September 1888 (3 pp.). 3. On a new self-recording thermometer (3 pp. and plate). 4. The thunderstorm of 16th October 1888 (2 pp.).

METEOROLOGISCHE ZEITSCHRIFT. Herausgegeben in Auftrage der oesterreichischen Gesellschaft für Meteorologie und der deutschen meteorologischen Gesellschaft. Redigirt von Dr. J. HANN und Dr. W. KÖPPEN. July and August 1889. 4to.

Contains: Ueber die milden Winde im grönländischen Winter, von A. Paulsen (9 pp.). This paper shows that the warm winds which Hoffmeyer always attributed to Föhn action are not really so produced, but are the winds in front of depressions, diverted on meeting the coast-line. They are damp not dry winds. —Zur Thermodynamik der Atmosphäre, von W. von Bezold (18 pp.). The two concluding parts of this paper appear in these Nos.—Die tägliche Periode der Feuchtigkeit in Christiania, von H. Mohn (7 pp.). This is a discussion of some observations taken hourly at the Christiania Observatory in 1841-3, and 1846-7, at the request of the Royal Society of London. They have been discussed by Herr Schroeter, assistant at the Meteorological Institute.—Die Niederschlagsverhältnisse in Galizien, von Dr. A. Wachlowski (5 pp.). This is an account of the rainfall organisation in Gallicia. The results are based on the observations of 39 stations, a number which the author hopes to increase.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. July-September 1889. Vol. XXIV. Nos. 282-284. 8vo.

Contains: The Paris Exhibition and its Congresses (3 pp.).—The Dorsetshire Waterspout of June 7th (4 pp.).—The Drought (4 pp.).—The Oak and the Ash (6 pp.).—Two great rainfalls, May 25th-30th, 1889 (4 pp.). At Sydney, New South Wales, 19·33 ins. of rain fell during the four days ending 9 a.m. on the 28th. At Hongkong the exceptionally large rainfall of 34·11 ins. occurred between 3 a.m. on the 29th and 4 p.m. on the 30th.—Waterspouts, by J. R. Lecky (2 pp.).—Another extraordinary rain in Essex (1 p.). During a thunderstorm on the night of September 2nd-3rd, very heavy rain fell in the neighbourhood of Romford. It is very remarkable that a similar exceptionally heavy fall occurred at the same place 13 months previously. The following are the amounts on both occasions:—

	August 1st, 1888.	September 2nd, 1889.
North Ockendon.	4·56 ins. besides what ran over.	4·55 ins.
Upminster Hall	4·50 „ „ „ „	4·32 „

—Two Shropshire Whirlwinds, August 21st (3 pp.).

THE SCOTTISH GEOGRAPHICAL MAGAZINE. Vol. V. No. 7. July 1889. 8vo.

In a paper on the Geography of the Caucasus, Herr V. Dingelstedt gives the following account of the Climatology. He says: With great local variations, the climate of the Caucasus may be roughly characterised as continental on the great Armenian plateau, in Eastern Transcaucasia and Ciscaucasia, and as maritime in the basin of the Rion, and on the narrow eastern shore of the Black Sea. The greatest variation between the mean highest and the mean lowest temperature of the hottest and coldest months of the year is presented in the high Armenian plateau, where, as in Erivan, it attains 97° Fahr. (mean monthly, January 14°·9, August 79°·2). It is least on the eastern shore of the Black Sea; for instance, at Sukhum it is only about 64° (mean monthly, January 43°·0, August 75°·9). The highest mean annual temperature (58°·5) was experienced in Lenkoran, Sukhum, and Poti, the lowest in Ardagan 36°·9 (6,019 feet above sea-level), and Gudaur 37°·9 (7,245 feet). There is no meteorological station at

a higher altitude than this last. Both records of temperature are open to question in view of the insufficient number of observations.

The distribution of moisture is most unequal: the eastern coast of the Black Sea and the south-eastern corner of Transcaucasia (the district of Lenkoran) are almost as rainy as Portugal, Norway, and the high Alpine valleys (from 47·3 to 83·2 ins.), whilst the western shore of the Caspian and some parts of the Armenian plateau are as dry as Castellon de la Plana (Spain) or even as Chenab (Punjab) —(about 9·1 ins.). The reason of this contrast is to be sought in the distribution of the mountains and the prevailing winds. The ramifications of the main chain north of Elbruz (Tashly-syrt) and South of Shkara (Meski or Suram) check the moist winds, and the moisture they contain is almost wholly discharged npon the western slopes of the mountains. The moist winds of the Caspian, on the other hand, are arrested by the mountain range of Talysh, and thus the vast country drained by the Terek and Kura is under the influence of dry winds, which is exemplified in the dreary desert of Ust-Urt.

The atmospheric pressure is highest in winter and lowest in summer. Of 100 windy days in summer there are about 72 days when the wind blows landward.

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THE END.

FIG. 1.

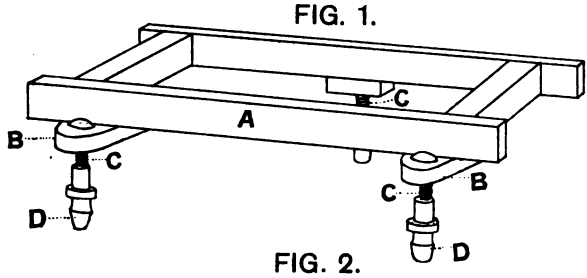

FIG. 2.

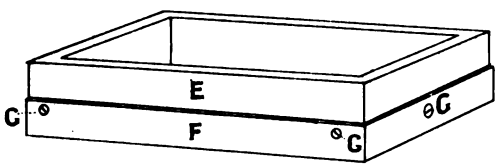

FIG. 3.

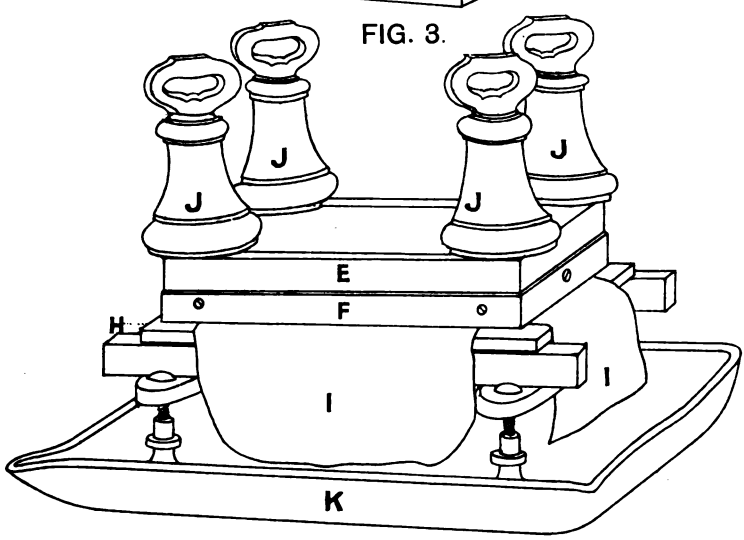

Fig 1.—**A**, A frame of wood on which is made to rest the sheet of plate glass **H**, shewn in figure **3**. **BB**, Blocks of wood to which are attached the screws **CC**. **DD**, Nuts made in the form of feet, and used to raise or lower the frame **A**.

Fig 2.—**E**, A frame of wood to which is attached the frame of brass **F**. This frame is made of "printers' rule," and is soldered at the four corners so as to be water-tight at the corners. It is so fixed that the lower edge is perfectly horizontal and at the same level all round, and is held in position by the screws **GGG**.

Fig 3—Shews the whole of the apparatus as it is when in action. The glass plate **H** is made to rest upon the frame **A**, and upon this is placed the frame **E** with its brass frame **F**. The curtains **I I** are of muslin, and are fixed lightly so as to assist in draining the water away. **K** Is a porcelain dish in which the whole apparatus stands. **JJJJ** Are iron weights used to prevent the water flowing away until the starch has deposited upon the sheet of paper.